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

VOLUME II

# WHAT THE LATEST SCIENCE ON IMPACTS, ADAPTATION AND VULNERABILITY MEANS FOR CITIES AND URBAN AREAS

SUMMARY FOR URBAN POLICYMAKERS

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

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

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SUP VOLUME I

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

SUP VOLUME II

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

SUP VOLUME III

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

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# THE SUP SERIES

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

The Summary for Urban Policymakers (SUP) series distils the IPCC reports into targeted summaries to inform action at the city and regional scale. Volume I in the series, *What the Latest Physical Science of Climate Change Means for Cities and Urban Areas*, identified the ways in which human-induced climate change is affecting every region of the world, and the cities and urban areas therein. In the coming years and decades, many cities and urban areas will be exposed to increased frequency and severity of extreme heat, an intensified water cycle including drought and heavy rainfall and floods, and an increased frequency of the most intense tropical cyclones and associated storm surge. More cities and urban areas will also increasingly experience the consequences of long-term sea-level rise, including coastal erosion and more frequent coastal flooding.

This second volume in the series, *What the Latest Science on Impacts, Adaptation and Vulnerability means for Cities and Urban Areas*, offers a concise and accessible urban-focused distillation of the IPCC Working Group II Report. The scale, reach, and complexity of contemporary urbanisation can compound the risks from climate change for cities.

Cities and urban areas have a critical role to play in delivering the climate resilient development needed to address these risks. This report assesses the feasibility and effectiveness, as well as the limitations, of different climate adaptation options. It explores the potential for maladaptation, or the triggering of unintended effects which may increase risk or greenhouse gas emissions (GHG). It synthesises the latest evidence on the need for urban-led transformation, the success of which will rely on activating five simultaneous systems transitions in: land, coastal, ocean, and freshwater ecosystems; urban, rural, and infrastructure systems; energy systems; industrial systems; and societal choices.[1] Finally, the report highlights opportunities for local governments to integrate urban adaptation and mitigation strategies to achieve sustainable development for all.

Gwangju, South Korea

# 1. INTRODUCTION

Between 2015 and 2050, an estimated 2.5 billion people will be added to the urban population with almost all this growth occurring in middle- and low-income countries.[2] This urban expansion will further concentrate climate change risks in the world's cities. Climate change exposes fault lines of inequality, poverty, poor governance, and inadequate infrastructure that undermine sustainable development in many cities.[3] Rapid urbanisation, and in particular, the rapid growth of unplanned and informal settlements in low- and middle-income nations and rapid urbanisation into hazard-prone areas, places large numbers of people beyond the reach of many formal climate policies and will require new approaches to climate resilient urban development.[4]

But cities and urban areas also sit at the center of the climate solution space. Global urbanisation is a 21st century megatrend, aggregating people, innovations, and investment, and enabling swifter action than is often possible at the national level. In this sense, urbanisation represents a crucial opportunity to accelerate climate responses required to limit warming to 1.5°C as well as work towards transformational adaptation and just, equitable, and climate resilient development (CRD).[5] The pursuit of CRD has the potential to deliver rapid, tangible benefits for marginalised urban dwellers, including cleaner air and water, reduced heat exposure and flooding, access to green space, and improved physical and mental health.[6]

Baguio, Philippines

***Climate change exposes fault lines of inequality, poverty, fractured governance and inadequate infrastructure that undermine sustainable development in many cities. A 21st century megatrend, global urbanisation aggregates people, innovations and investment, enabling swifter action than is often possible at the national level.***

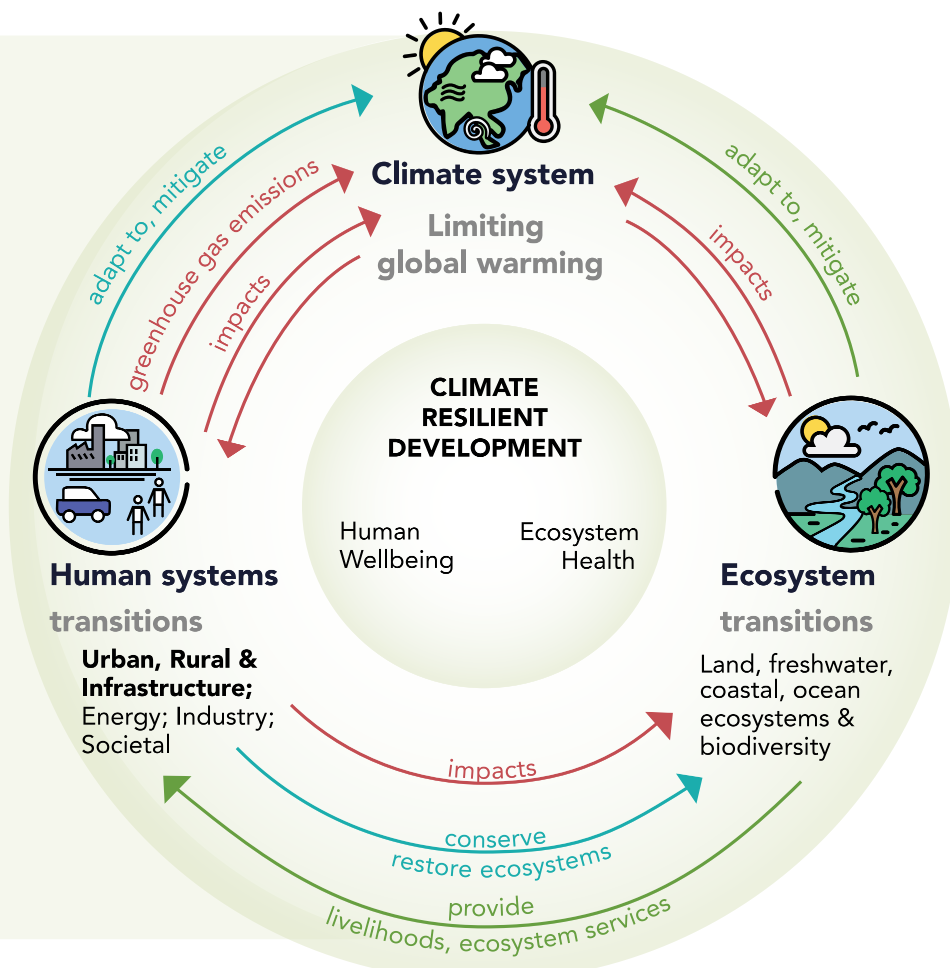
Published in August 2021, AR6 Volume I *The Physical Science Basis* offered the most current and comprehensive scientific understanding of changes to the physical world as a result of human activities. As volume 1 of the Summary for Urban Policymakers series, *What the Latest Physical Science of Climate Change Means for Cities and Urban Areas*, confirms, even with stringent $C0_2$ and other GHG emission reduction, decreased emissions will continue to add to the planet's cumulative $CO_2$ budget. This will lead to warming above 1.5°C in the next 20 years. However, without immediate deep reductions in GHG emissions, global warming will exceed 2°C by around 2050. Such warming increases the frequency, duration and severity of extreme weather and high-impact events whose effects are exacerbated in cities and urban areas.

While a range of climate change risks coalesce and aggregate in cities and urban areas, they have differing impacts across regions, sectors, and communities. Risks come from a dynamic interaction between climate-related hazards and the exposure and vulnerability of affected human or ecological systems.[7] Risks in urban areas are reduced by interventions aimed at decreasing vulnerability and exposure to hazards, as well as broader adaptation and mitigation responses to climate change.[8] Presented in a modified version in Figure 1, the AR6 risk framework examines the severe, interconnected, and sometimes irreversible impacts of emissions from urban areas on climate change and ecosystems, and in turn climate impacts on urban areas and linked economic and social systems, ecosystems, and biodiversity.

**Figure 1: Climate Resilient Development through transitions in climate, ecosystems and human society**

*Human systems and ecosystems are interconnected. To move towards goals of human well-being and ecosystem health leading to overall CRD, system transitions are needed, of which the urban, rural, and infrastructure systems transition is vital. Key enablers for climate adaptation and CRD include inclusive governance and institutional capacity; finance; monitoring and evaluation; technology and innovation; lifestyle and behaviour change; and attention to culture and heritage.*

*Source: Derived from IPCC AR6 WGII, Summary for Policymakers, Figure SPM.1.*



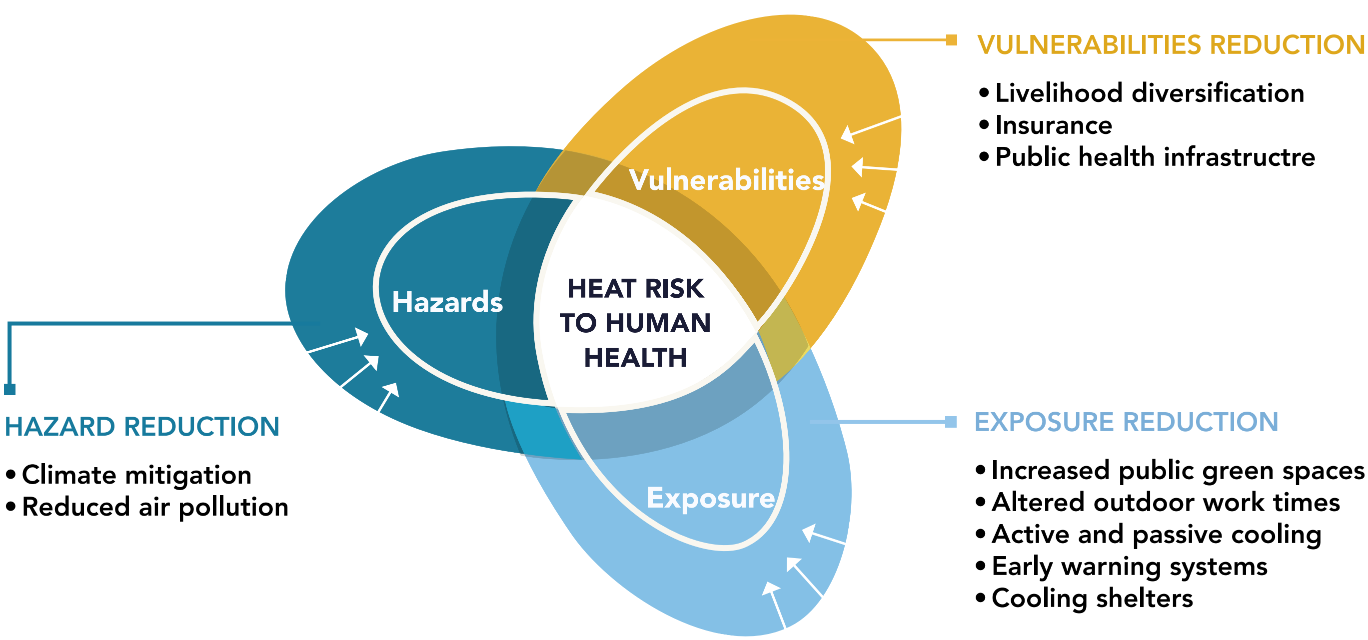
# 2. RISK CREATION AND CONCENTRATION IN CITIES AND URBAN AREAS

Understanding the need for, and feasibility of, urban-led transformations requires further exploration of the current and future hazards and exposure to them, as well as vulnerabilities in cities and urban areas.

The risk framework also provides insights on reducing adverse consequences for current and future generations by modifying hazards, and reducing vulnerabilities and/or exposure.[9] Exposure to hazards can be reduced by altering the physical form of urban areas, managing population and infrastructure growth, and modifying physical hazards along coasts and rivers.

Vulnerability can be reduced through efforts to promote inclusive development and to reduce inequality. The lack of or inappropriate responses can potentially increase vulnerability and overall risk. In addition, some adaptation responses can lead to maladaptive outcomes.[10] Responses that reduce risks can be enhanced by enabling conditions, including prudent and transparent multilevel governance, access to finance, improved institutional capacity, and behavioural change.[11]

**Figure 2: Risk is a function of hazards, exposures, vulnerabilities, and adaptive capacities; all of which are mediated by mitigation and adaptation responses.**




*Risks from climate change result from dynamic interactions between hazards, exposures, and vulnerabilities; as well as from the adaptation and mitigation responses to modify hazards and reduce exposure and vulnerabilities. An illustrative example of one risk in cities and urban areas - heat risk to human health - is represented in the figure above.*

*Source: Derived from IPCC AR6 WGII, Chapter 1, Figure 1.5(d)*

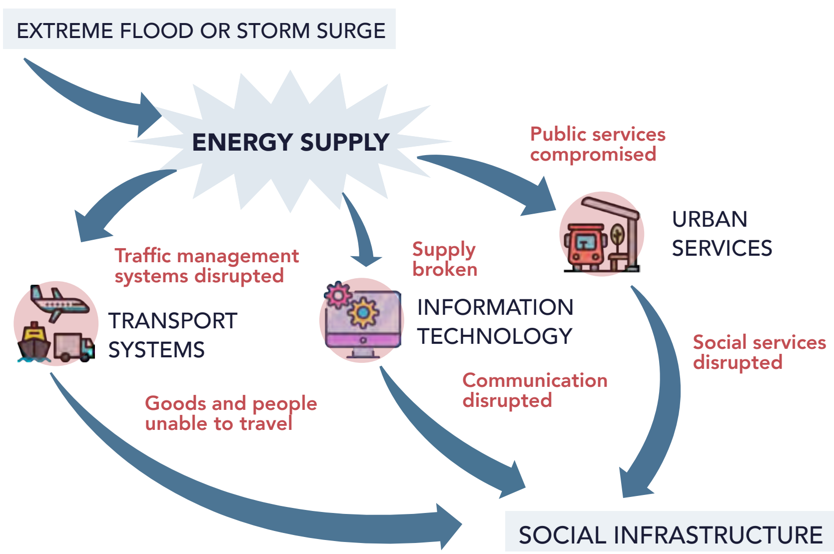
More than 4 billion people live in cities, and the global urban population has risen by more than 400 million between 2015–2020. If the global population moves from 8 to 11 billion by 2050, the urban population could double.[12] Much of this growth would be expected to occur in Asian and African cities and urban areas, particularly in informal settlements that house the most vulnerable and have greater exposure to climate hazards.[13]

- Asia, the world's second most urbanised region, with very high levels of poverty and informality, is home to seven of the eight megacities worldwide that are most vulnerable to disasters: Jakarta, Karachi, Kolkata, Manila, Osaka, Tianjin and Tokyo, which all have a population of over 10 million people.[14]
- In Africa, the world's most rapidly urbanising region, increasing climate risks in rapidly growing cities and urban areas are exacerbating pre-existing stresses related to poverty and socioeconomic exclusion. The number of days urban residents are exposed to extreme heat will increase dramatically with warming, with greatest exposure in West Africa. Relative to 2000, the amount of urban land exposed to high-frequency flooding and aridity across West, Central and East Africa is expected to rise by 2,600% and 700%, respectively, by 2030.
- Central and South America possess five megacities and over 100 secondary cities, many of which have very high levels of socioeconomic inequality, poor and unevenly distributed infrastructure, housing deficits, and the recurrent occupation of risk areas. Increasing temperatures and heatwaves are leading to higher water demand, damaging urban infrastructure, and accelerating tree ageing and death.[15]
- Nearly one-third of European cities show vulnerability to heatwaves, drought, and floods. In more than 10% of European cities at least one-quarter of the population lives within potential river floodplains.[16]
- North American cities are experiencing increasing severity and frequency of climate hazards and extreme events such as heatwaves, sea -level rise, storm surges and flooding, with particularly unequal outcomes for vulnerable groups based on income, ethnicity, and race.[17]

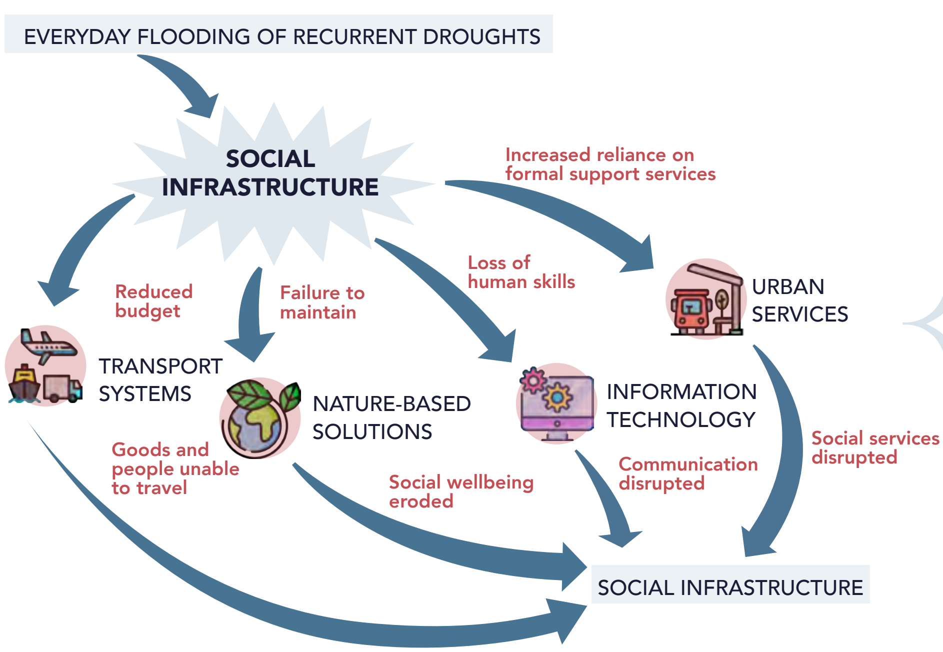

*Dhaka, Bangladesh*

Finally, as captured in Figure 3, urban risks stretch beyond urban areas, effectively linking rural and urban infrastructures, populations, and ecosystems, into interconnected and co-dependent systems, with implications for strategic investment in risk reduction and climate adaptation. Systemic risk, originating in urban risk, cascades into rural areas and regions as cities and urban areas host key sites for productive industries and employment with disruption impacting supply chains and flows of money, including through remittances from urban migrants.[18] Similarly, impacts and risks in more rural areas can impact cities and urban areas through, for example, food and water scarcity.

**Figure 3: Climate impacts cascade through infrastructure across sectors**




A flash flood damages energy supply, for example by flooding an electricity sub-station. This impact cascades to associated sectors and services such as transport, IT and urban services, producing a compounded impact on social infrastructure, wellbeing and future vulnerability.




Chronic climate impacts such as everyday flooding put pressure on social infrastructure over time. Strained livelihoods, health and education services challenge city budgets and place additional demands on formal services. These impacts place further pressure on already constrained urban social infrastructure generating vulnerabilty.

*Source: Derived from IPCC AR6 WGII, Chapter 6, Figure 6.2*

## Future risks and vulnerability

At higher levels of warming, risks to cities and urban areas and their essential infrastructure will increase significantly. Global warming of 1.5°C in the near-term will increase unavoidable climate hazards and risks to ecosystems and humans.[19] At 1.5°C warming, without adaptation, an additional 350 million people living in cities and urban areas will experience the effects of severe drought, including water scarcity. At 2°C warming, that number grows to around 410 million.[20] Globally, 1 billion people live in areas at risk of coastal hazards by 2050. In that same year, 250,000 excess deaths per year are projected from climate change, with leading causes including heat, undernutrition, and diarrhoeal diseases.[21] Urban populations will experience increased exposure to heatwaves, and as well an increased burden of several climate-sensitive foodborne, waterborne, vector-borne, and non-communicable diseases.

By 2100, coastal flooding in cities from sea-level rise will affect between 158–510 million people, and expose USD 7.9–12.7 billion of infrastructural assets to flood damage. Risks to people, land, and infrastructure are highest in coastal areas of East and South-East Asia.[22] Urban infrastructure costs, including for maintenance and reconstruction of buildings and transportation hubs and networks, will increase with warming. Significant functional disruptions are projected for cities and urban areas located on coastlines and permafrost.[23] Progressive warming could lead to involuntary migration, especially from regions with high exposure and low adaptive capacity.[24] Intensification of precipitation, tropical cyclones, and drought, as well as increasing sea-level rise, is expected to increase displacement in the mid- to long-term. Meanwhile, even if warming stops, sea level rise is committed beyond 2050, escalating beyond 2100 and continuing for centuries to come, with direct impacts on urban areas along coastlines and cultural and natural heritage.[25]

*Venice, Italy*

*Island of Seychelles*

The increase in risks and impacts, while global, affect populations and regions differently. or example in the European Union, current annual damages to energy infrastructure of €0.5 billion $yr^{-1}$ are projected to increase 1612% by the 2080s, in China, 34% of the population are vulnerable to electricity supply disruptions from a flood or drought, while in USA, higher temperatures are projected to increase power system costs by about USD 50 billion by 2050.[26] Exposure to climate hazards intersects with pre-existing, differential vulnerability based on gender, class, race, ethnicity, age, and resource access. It is also framed by cultural norms, diverse values, and practices.[27] Even if hazards associated with climate change were not projected to grow, increasing trends in urban inequality, precarious livelihoods, inadequate access to key infrastructure, and exclusionary decision-making processes indicate heightened vulnerability and therefore higher range and severity of risk to existing hazards. It is the combination of growing hazards associated with climate change, exposure to multiple climatic and non-climatic hazards, and worsening social and economic inequality and vulnerability, that drives an increase in climate change risks.

The evidence from urban and rural settlements is clear: climate impacts are felt disproportionately in communities that are most economically and socially marginalised. These effects are especially strong in smaller and medium-sized cities of Asia, sub-Saharan Africa and Central and South America.[28] In Central and South America and Africa, 22% and 59% of the urban population, respectively, live in informal settlements and are particularly vulnerable due to limited employment opportunities and infrastructure.[29]

With current policies, the world is on track for a temperature increase of 3°C or more by 2100. In the absence of stronger climate policy, warming above 4°C cannot be ruled out.[30]

At global warming levels of 1.1°C, cities and urban areas are experiencing significant and diverse impacts from climate change, especially related to health, livelihoods, and key infrastructure. And some major cities have already moved beyond 1.5°C of mean local warming. In short, urban policymakers should design adaptation policies and plans on the assumption that the average global temperature rise will exceed 1.5°C. The next section lays out the most recent science on adaptation gaps and limits.

***With current policies, the world is on track for a temperature increase of 3°C or more by 2100. In the absence of stronger climate policy, warming above 4°C cannot be ruled out. Urban policymakers must design adaptation policies and plans on the assumption that the average global temperature rise will exceed 1.5°C, and potentially exceed 2.5°C for significant lengths of time over the century.***

*Espargos, Cape Verde*

# 3. ADAPTATION GAPS AND LIMITS

Cities of varying sizes and locations have developed adaptation plans, and over 170 nations have included adaptation in their policies and planning processes.[31]

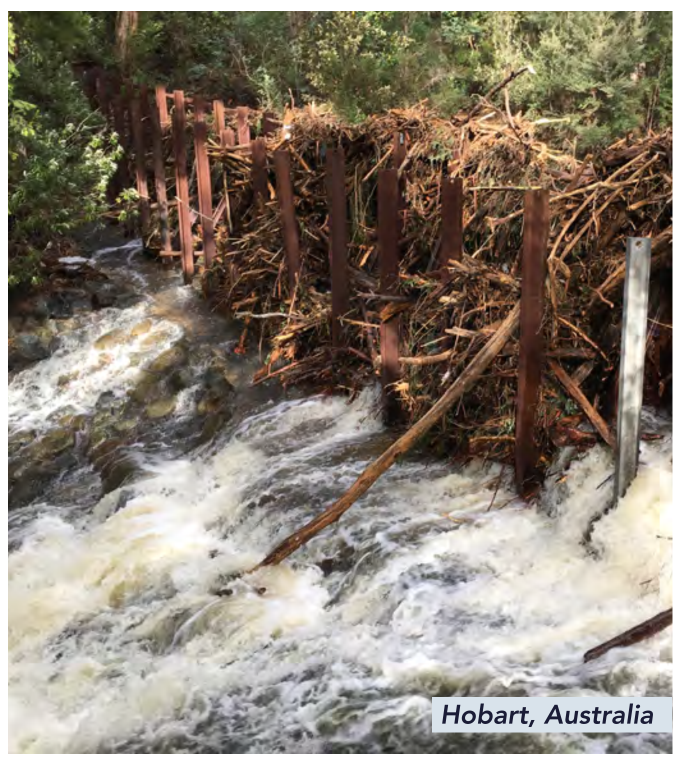
However, cities often face challenges when it comes to implementation, with only a limited number of city adaptation plans implemented to date. Further, many of these adaptation strategies focus narrowly on climate risk reduction, and while generally meant to be complementary to city-wide climate mitigation and/or sustainable development plans, a more integrated approach can create significant opportunities for co-benefits.[32] Near-term mitigation is essential to retain the space for such adaptation. Rapidly decreasing GHG emissions remains the most effective way to reduce future risks.[33]

## Adaptation gaps

The development and implementation of adaptation plans and policies differ by region. As noted in the next section on knowledge gaps, there remains a significant gap in the peer-reviewed literature assessed for this report on city-level adaptation planning and implementation; however, the following observations can be made by region:

- Asian cities are undertaking adaptation actions but a majority of them focus on preparatory actions and capacity building for single hazards.[34] Even key port cities at high risk from climate impacts report that adaptation interventions constitute only a small proportion of cities' climate efforts.
- In North America, adaptation planning and implementation to address sea-level rise and coastal flooding have been initiated by many cities, though preparedness varies.[35]
- Adaptation progress across African cities has been slow, especially in West and Central Africa.[36] More than 80% of Africa's large coastal cities have no formally adopted adaptation policies, and planned adaptation initiatives in African cities have been predominantly determined at the national level with negligible participation of lower levels of government. While urban adaptation continues to be dominated

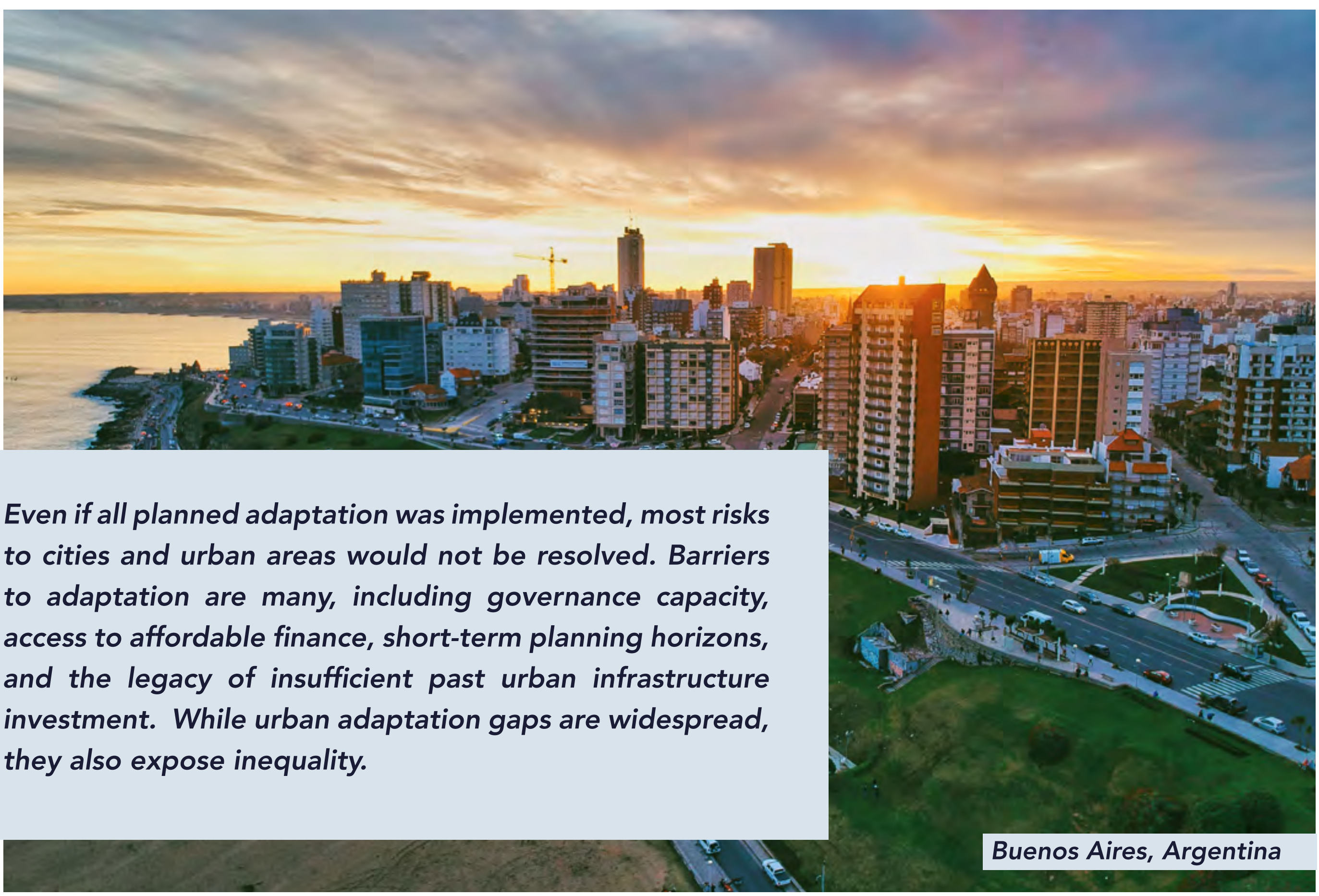

Cascais, Portugal


Hobart, Australia

by autonomous, informal responses by households, there are emerging examples of planned adaptation in cities such as in Durban, Cape Town and Lagos, and of community-led projects in cities such as Maputo. An increasing number of ecosystem-based adaptation projects such as restoration of mangrove, wetland, and riparian ecosystems have been initiated, with demonstrated long-term health, ecological, and social co-benefits, particularly addressing water-related climate risks and lengthening the life of existing built infrastructure.[37]

- Adaptation initiatives in Central and South America, meanwhile, have focused on regulation and planning, albeit still short-term, and urban water and housing management. Housing initiatives to improve informal and precarious settlements have been widely carried out in the region, but prioritising disaster reduction without incorporating resilient construction parameters or aligning policies of access to land and decent housing with community-based adaptation strategies. Comprehensive adaptation policies that include development and the reduction of poverty and inequality in the region will be necessary in order to engage diverse stakeholders for transformational adaptation.[38]
- Across Europe, adaptation planning in cities and urban areas, settlements and key infrastructures has increased. Many smaller cities and those with relatively lower GDP per capita still lack adaptation planning.[39] Gaps remain, on implemented adaptation, adaptation by private actors, and against sea level rise. While almost all large municipalities in Northern and Western Central Europe have implemented actions in at least one sector, nearly 40% of municipalities in Southern Europe have not yet done so. There are emerging examples of transformative urban adaptation, in Hamburg and Rotterdam , for example, but they remain pilots.

Critically, adaptation strategies already implemented or even just planned are insufficient to meet the current levels of risk associated with climate change. Put another way, even if all planned adaptation was implemented, most risks to cities and urban areas would not be resolved.[40] Urban adaptation gaps exist in all regions, as they do for all hazard types.



***Even if all planned adaptation was implemented, most risks to cities and urban areas would not be resolved. Barriers to adaptation are many, including governance capacity, access to affordable finance, short-term planning horizons, and the legacy of insufficient past urban infrastructure investment. While urban adaptation gaps are widespread, they also expose inequality.***

Buenos Aires, Argentina

**Figure 4: The Urban Adaptation Gap**


*Source: Derived from IPCC AR6 WGII, Chapter 6, Figure 6.4*

This is not simply a question of implementation. Barriers to adaptation are many, including governance capacity, access to affordable finance, short-term planning horizons, and the legacy of insufficient past urban infrastructure investment.[41] As Figure 4 illustrates, while urban adaptation gaps are widespread, they also expose inequality. In some regions, the gaps are higher for food insecurity and flooding than for heatwaves; but in all cases, poorer neighbourhoods, cities and urban areas, and regions face larger gaps than their wealthy counterparts.[42]

## Adaptation limits

Even when fully implemented, there are limits to adaptation, particularly as warming increases. The greater the warming, the larger the impacts, and the more difficult it becomes to adapt, ultimately hitting hard limits, where no adaptive actions are possible to avoid intolerable risks.[43] Some coastal communities reliant on nature-based coastal protection will hit hard limits beginning at 1.5°C. The autonomous and evolutionary adaptation responses of terrestrial and aquatic species and ecosystems will also begin facing hard limits beginning at 1.5°C global warming.[44] Both hard limits, or conditions beyond which it is impossible to adapt, and soft limits, conditions that can limit adaptation because solutions are not available to certain people based on assets or capacities, are shaped by differences in levels of development, often leading to disproportionate impact on vulnerable groups. Geography is also an important factor, with coastal cities and urban areas, for example, likely to approach such limits before 2100 owing to risks related to sea-level rise and tropical cities and urban areas, in South and West Asia for example, approaching thermal limits due to high humid heat by 2060.[45]

*Izmir, Türkiye*

## Knowledge gaps

While efforts to track urban adaptation have been improving dramatically, inconsistencies remain in methods, metrics, and data gathering.[46] Specifically, in major cities around the globe, peer-reviewed monitoring and evaluation of government-led urban adaptation is largely missing, even if it is captured and updated by global city networks or related NGOs.[47] Important gaps in instrumental knowledge include: event loss and damage data; city-relevant climate data; and data on adaptation experiments within and between governments, as well as including civil society and the private sector.[48] There are also key gaps in inclusive knowledge, or who's asking and who's answering. These include: Indigenous knowledge and local knowledge that brings together top-down and bottom-up capacities, as well as gender and child-sensitive planning.[49] Finally, key knowledge gaps remain concerning the systems transitions themselves, such as: understanding urban decision making support systems including the functioning of multi-level governance; monitoring and evaluation of adaptation projects, programmes, and spontaneous actions; and opportunities for peer-to-peer learning from local to international exchanges.[50]


*Kathmandu, Nepal*

# 4. ADAPTATION ACTION

Day-to-day decisions on the economy, nature, and infrastructure shape the adaptation options available to people living in cities and urban areas around the world. Avoiding lock-in of particular urban development trajectories that amplify climate risk or constrain the set of adaptation options is a central challenge for decision makers. While adaptation continues to focus overwhelmingly on interventions oriented around physical infrastructure, there are other measures and approaches through which greater urban resilience can be achieved. This growing range of urban adaptation options, detailed below, has been tested by experience.

## Urban planning

The built environment and urban form mediates climate vulnerability, including, as Box 1 explores, in coastal cities and urban areas. A lack of open green spaces, for example, can exacerbate heat and flood risks. Planning that uses system-wide climate risk assessments and regulation, including climate-adapted land use and building performance, can help steer residents away from areas that are highly exposed to risks, and coordinate and foster effective private and public investments in adaptation and CRD.[51] Urban planning can also support coordinated and integrated adaptation and decarbonisation by mainstreaming climate concerns. For example, city plans can promote compact urban development with the co-location of jobs and housing to reduce the extent of land-use change and transport energy consumption. Such compact development patterns protect ecosystems that mitigate extreme heat, provide natural flood defences, offer habitats that improve biodiversity, and store carbon. Given lock-in, built environment adaptations should take care to avoid potential negative impacts on social equity and carbon-intensive construction.[52]

New York, USA

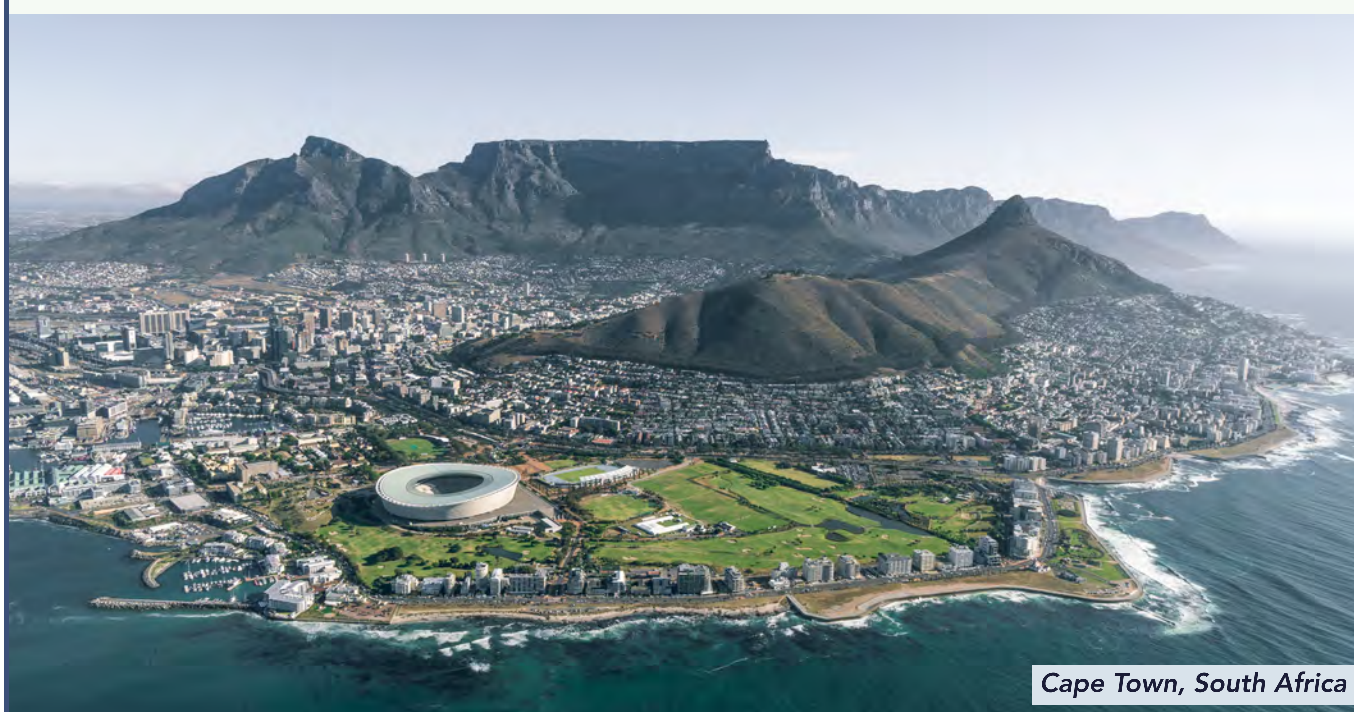
## Adaptation Pathways for Sea-level Rise in Coastal Cities and Urban Areas

Combining and sequencing adaptation interventions can reduce risk, spread costs, and minimise lock-in. Breaking adaptation into manageable steps over time may help local policymakers explore alternative adaptation pathways. This flexible approach can accelerate adaptation action by allowing policymakers to prioritise between near-term and future options, and to manage uncertainty through monitoring, learning, and subsequently updating their strategy.

For cities in particular—as illustrated in Figure 5 on adaptation pathways for coastal cities and settlements to sea level rise—considering the full sequence of adaptation options allows policy makers to anticipate critical decision points, identify triggers and avoid decisions that block certain options in future.[53] Identifying and exploring such pathways is especially important for coastal cities given the immediacy and intensity of impact under high-warming scenarios, the long-term certainty of continued sea-level rise, and the long time horizon to plan and deliver effective adaptation responses.

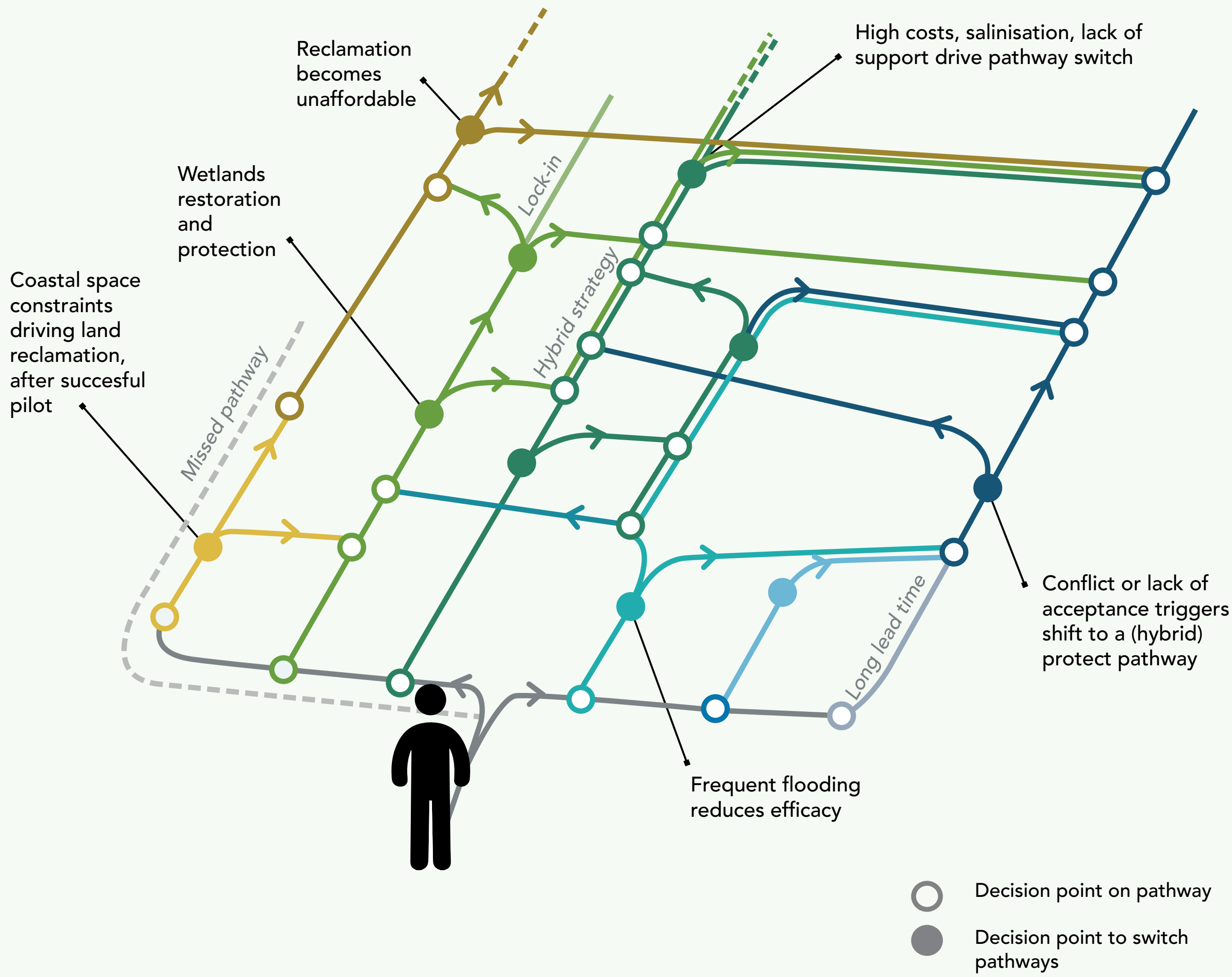
The impacts of sea-level rise can be somewhat mitigated by preventing new developments in vulnerable and exposed areas. Meanwhile, a range of adaptation options are available for existing developments. Many megacities have elected to invest in "hard" protection pathways for water adaptation infrastructure, such as sea walls. However, such hard protection pathways can become increasingly costly, institutionally challenging, and do not reduce the risk of salinisation of coastal land. A hybrid strategy that integrates nature-based solutions, such as retaining retaining and restoring mangroves and marshes, can reduce further risk, reduce cost, and provide additional livelihood and biodiversity benefits. While maintaining a hard protection pathway may be preferred because of costs associated with switching to an alternative pathway, transitioning away to softer adaptation options can prove less costly in the long-term. Finally, retreating from the coast through planned relocation or migration can effectively reduce risk and provide opportunity for re-establishing coastal ecosystems, but requires careful and inclusive planning in source and destination settlements.[54]

**Box 1.**



*Cape Town, South Africa*

## Figure 5: Coastal Cities & Settlements: Indicative Adaptation Pathways for Sea Level Rise




| Strategies | Examples of Adaptation Options | Strategies | Examples of Adaptation Options |
|---|---|---|---|
| Advance | New seawards land reclamation above sea level | Accommodate | Wet and dry proofing built environment; Floating cities (experimental, not shown) |
| Protect | Sea walls, levees, storm barriers; Wetlands, mangroves, coral reefs | Retreat | No build zones; Planned relocation |

*Source: Derived from IPCC AR6 WGII, Cross-Chapter Paper 2, Figure CCP2.4*

## Infrastructure

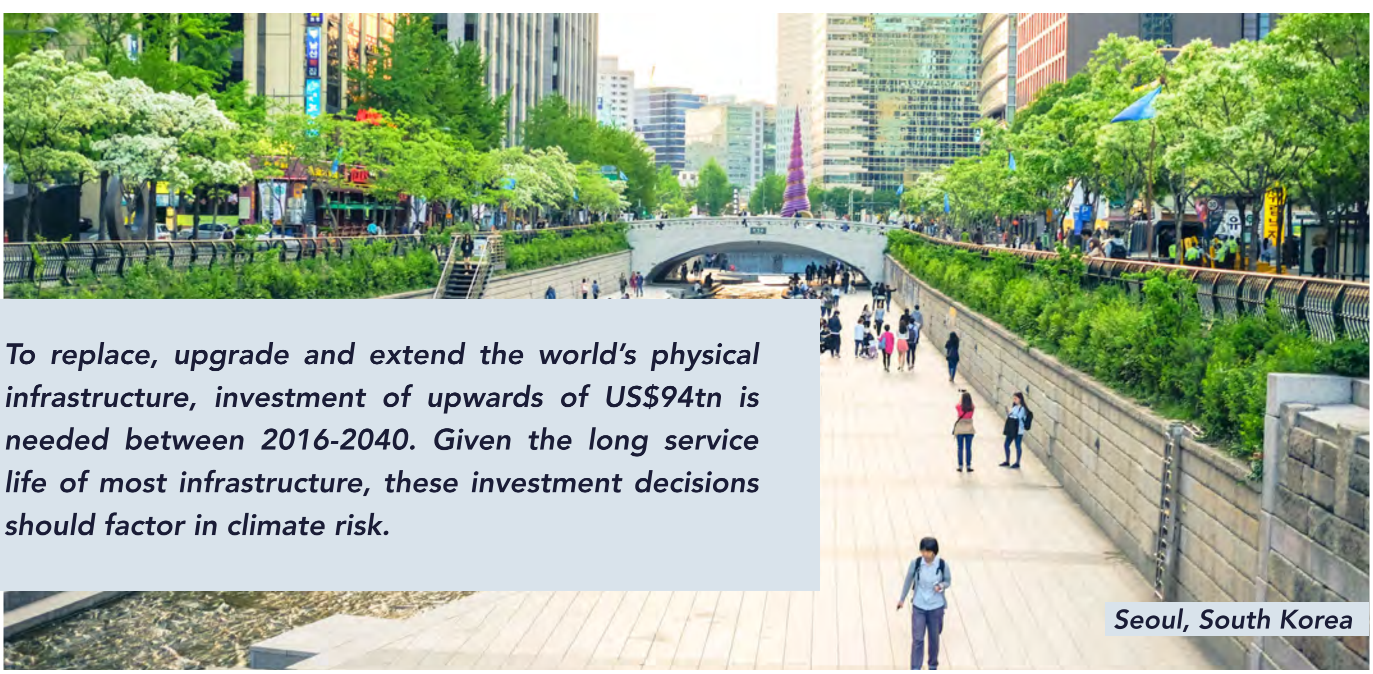
Investment in low-carbon and resilient infrastructure can meet pressing human and economic needs today while providing an opportunity for medium- to long-term climate resilient development. To replace, upgrade, and extend the world's physical infrastructure, investment of upwards of USD 94 trillion is needed between 2016 and 2040. Given the long service life of most infrastructure, these investment decisions should factor in climate risk.[55]

An increasing number of adaptation options exist for key infrastructure sectors and for all stages of the infrastructure life cycle from planning, design, and delivery to operation and maintenance. The suitability of these options depends on existing infrastructure systems, location, governance capacities, and access to finance.[56] Engineered climate resilience-building measures are being implemented in urban centres, but high construction and maintenance costs make many of these interventions less accessible in low- and middle-income countries. Further, high material and operations energy intensity of these measures can conflict with decarbonisation efforts.[57]

Many cities and urban areas lack sufficient infrastructure relating to water supply, sanitation, electricity, transport, and housing, with the shortfalls concentrated in informal settlements.[58] These development deficits interact with climate hazards to increase vulnerability.[59] As such, addressing these basic deficits while improving climate-adapted performance and integrated long-term planning creates significant opportunities for adaptation in less wealthy cities. Upgrading informal settlements—including through investment in climate resilient infrastructure—can improve living standards, while enhancing resilience to climate impacts as well as other hazards.[60] Despite the importance of achieving the SDGs and advancing adaptation, there is limited evidence of resilient infrastructure investment in informal settlements.[61]

## Nature-based solutions including Ecosystem-based adaptation

Solutions that engage nature, explored further in Box 2, are increasingly employed in cities to protect, sustainably manage, and restore natural or modified ecosystems for disaster risk reduction and effective adaptation. When focussed on adaptation, these are called ecosystem-based adaptation (EbA) measures. EbA measures use ecosystem management to increase resilience and reduce vulnerability of people and ecosystems to climate change.[62] Nature-based solutions (NbS) pertain to a wider range of actions expected to have adaptation and mitigation co-benefits, including the protection and restoration of forests and other high-carbon ecosystems.[63] There is growing evidence that these solutions can contribute to climate adaptation and mitigation and hold co-benefits for human health



*To replace, upgrade and extend the world's physical infrastructure, investment of upwards of US$94tn is needed between 2016-2040. Given the long service life of most infrastructure, these investment decisions should factor in climate risk.*

*Seoul, South Korea*

### Leveraging Nature for Urban Adaptation

Street trees, green roofs, green walls, and other urban vegetation can provide low-cost means to reduce air temperature and the impacts of heat waves by cooling private and public spaces through shading and evapotranspiration.[64] Vegetated barriers along streets or in urban forests can also reduce particulate matter, the ambient air pollutant with the largest global health burden.[65] Blue infrastructure, including rivers, streams, ponds, lakes, and wetlands, provide cooling in addition to other ecological and hydrological functions critical to sustainable urban water management. Grassland, riparian buffers, and forested watersheds can enhance water filtration into the soil, protecting against urban flood and drought while mangroves and coastal wetlands reduce storm surges and coastal flooding.[66]

Well-designed green and blue infrastructure can have significant advantages over grey physical infrastructure: they are often cheaper to construct and maintain, while safeguarding biodiversity and human health. By comparison, grey infrastructure can seal off soil or bury streams, thereby increasing flood risk and altering the hydrology necessary to sustain ecosystems and livelihoods. NbS may yield co-benefits such as contributing to food supply, providing recreational spaces, or improving mental health.[67] Carbon-rich ecosystems in urban areas, such as wetlands and forests, also store and sequester carbon, thus linking adaptation and mitigation.

Political commitment and swift, persistent, and consistent action to scale up investments in NbS are needed to close the climate adaptation gap.[68] NbS have huge potential to advance CRD in cities but do not typically receive sufficient recognition or investment. NbS can be implemented in combination with hard protection measures to create a hybrid strategy that can enable large-scale impacts by, for example, combining stormwater drains, sewers, and urban wetlands to manage and filter run-off. Successful NbS require site-specific knowledge and science-based design, pilot monitoring, adaptive upscaling, and understanding of long-term performance, maintenance, and costs.[69] Inequitable access to NbS can be addressed by prioritising investments in risk and vulnerability hotspots, such as in communities exposed to high heat or lacking urban tree canopy or accessibility to parks.[70]

Such solutions can also be maladaptive. For example, urban greening projects can privilege wealthy urban residents, drive up property prices, and change neighbourhoods. Local, inclusive community planning is important to ensure benefits are equitably distributed and protects the most vulnerable.[71] Still, there is clear evidence that carefully planned and locally relevant NbS implemented as part of a city's suite of climate responses can reduce risk, mitigate GHGs, and deliver multiple health and development benefits.

Box 2.

and well-being, and local biodiversity across household, neighborhood, municipal, and regional scales. Yet, these solutions that engage nature, EbA and NbS, are vulnerable to climate change impacts. Hence, they may have limited feasibility at higher degrees of warming if deep cuts in GHG emissions are not implemented.[72]

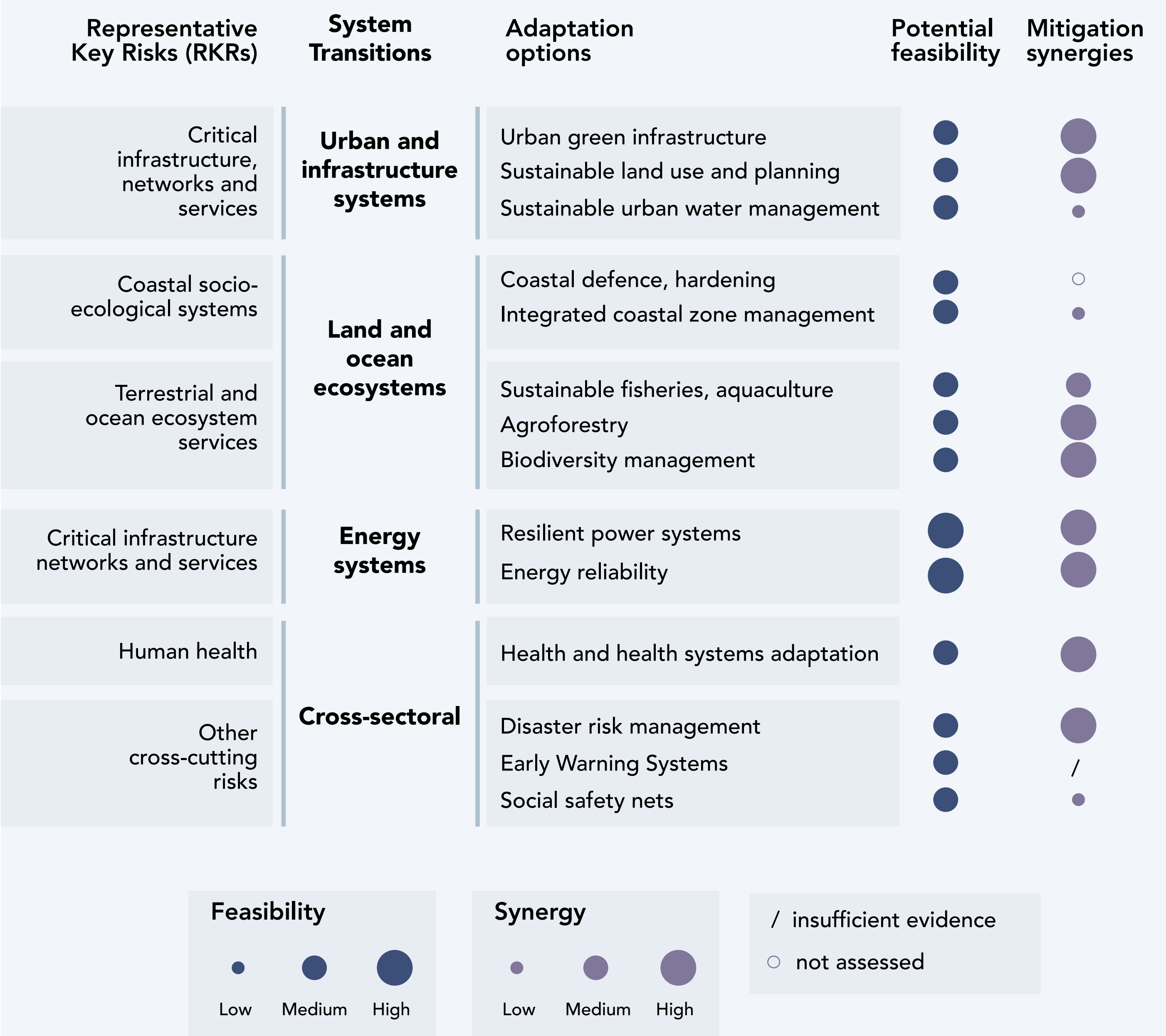
## Social infrastructure and systems

Development of social infrastructure and systems is integral to adaptation planning and implementation. These include healthcare, education, social safety nets, inequality reduction programmes, and disaster risk management tools including insurance,. Strong and equitable healthcare systems can protect the health of populations in the face of known and unexpected stressors.[73] Disaster risk management is highly feasible when supported by strong institutions, inclusive governance, local engagement, and trust across actors. Integration of worldviews, belief systems and Indigenous knowledge and local knowledge into disaster risk management can facilitate successful, disability-inclusive, and gender-focused adaptation.[74]

As Figure 6 illustrates, climate services, such as early warning systems and seasonal forecasts, build adaptation capacity and enable short- and longer-term risk management decisions.[75]

Efforts to adapt may have to speed up and can be accelerated by closer collaboration between the diverse actors deploying adaptation. Establishing linkages between multiple levels of government and with the private sector and civil society can help deliver coordinated action across the range of adaptation options and processes of strategic visioning, planning, experimentation, capacity building, construction of coalitions, and communications. Local authority capacities and willingness are important enablers.[76] Growing awareness of how drivers of urban change and vulnerability interact has motivated an interest in transformational approaches to adaptation that can link incremental adaptation actions to accelerated or alternative development efforts, taking care to ensure greater inclusion in urban decision-making and equity in the distribution of outcomes.[77]

**Figure 6: Multidimensional feasibility of select climate responses and adaptation options organized by System Transitions and Representative Key Risks (RKRs)**




*Source: Derived from IPCC AR6 WGII Summary for Policymakers, Figure SPM.4A*

# 5. CLIMATE RESILIENT DEVELOPMENT AND TRANSFORMATION IN CITIES AND URBAN AREAS

Climate resilient development (CRD) presents a framework and process that allows cities and urban areas to undertake activities that simultaneously promote climate adaptation, mitigation and sustainable development, while highlighting the role of equity, inclusion, and justice in pursuing necessary actions.[78]

As interest in CRD as an approach to urban planning, design, and development has accelerated in recent years, the assessed knowledge on what conditions can promote or hinder CRD has also begun to build. This section offers an overview of the state-of-the-art knowledge around CRD and explores how cities can promote emerging and established best practices.

## CRD: what we know

In terms of both actions and timeframes, CRD extends beyond previously explored adaptation approaches. Climate adaptation often is associated with specific projects or discrete actions, and is typically short-term in its time horizon. Adaptation expands into CRD when it explicitly connects to sustainable development and mitigation, taking a longer time horizon, involving a broader array of stakeholders, making active choices to accelerate deep transformational change, and recognising multiple pathways with different synergies and trade-offs attached to specific actions and decisions. Adaptation and mitigation action, as well as sustainable development, are interdependent processes. Pursuing climate and development goals in an integrated manner increases their effectiveness in enhancing human, ecosystem and planetary health.

Opportunities for CRD are diminishing and not equitably distributed around the world. CRD prospects are increasingly limited if GHG emissions do not peak and net-zero targets, both global and regional, are not met. Globally, climate actions that advance the synergies of mitigation, adaptation, and sustainable development have occurred slowly and unevenly. Climate impacts and risks increase ongoing and acute

Vancouver, Canada

development challenges. This is especially the case in developing regions and sub-regions, as well as on coasts and small islands, and in deserts, mountains, and polar regions. The increase in vulnerability and economic and social inequalities associated with such impacts and risks undermines efforts to achieve sustainable development in urban areas.

Cities and urban areas offer critical spaces to realise adaptation and mitigation simultaneously with significant potential co-benefits, while also pre-empting potential trade-offs. Renewable-energy based electrification, for example, can improve indoor and outdoor air quality, thus resulting in better respiratory health for urban dwellers. Green and blue urban infrastructure has the potential to sequester or store carbon, as well as to reduce urban heat island effects and flooding associated with stormwater run-off.[79]

Given projected rapid changes in the built environment, opportunities for enhanced use of sustainable materials, and promotion and mainstreaming of land-efficient low-carbon urban development, the next decade and beyond will be critical. Much of the new urban development in the short and medium term future will be self-built and informal, requiring new modes of governance and planning.[80]

Effective adaptation requires focus on inequity in climate vulnerability and responses. CRD efforts will be most effective when linked with conditions that promote social and environmental justice; and, conversely, conditions of inequity and exclusion are understood to limit CRD efforts. Sustainable development, when linked with a rights-based approach, can advance prosperity, human well-being, equity, and climate justice. A balance of power and participation across stakeholders are needed for effective climate action, including: prioritising investments to reduce climate risk for low-income and marginalised residents; participatory planning of urbanisation, infrastructure, and risk management; and monitoring climate action for climate justice.

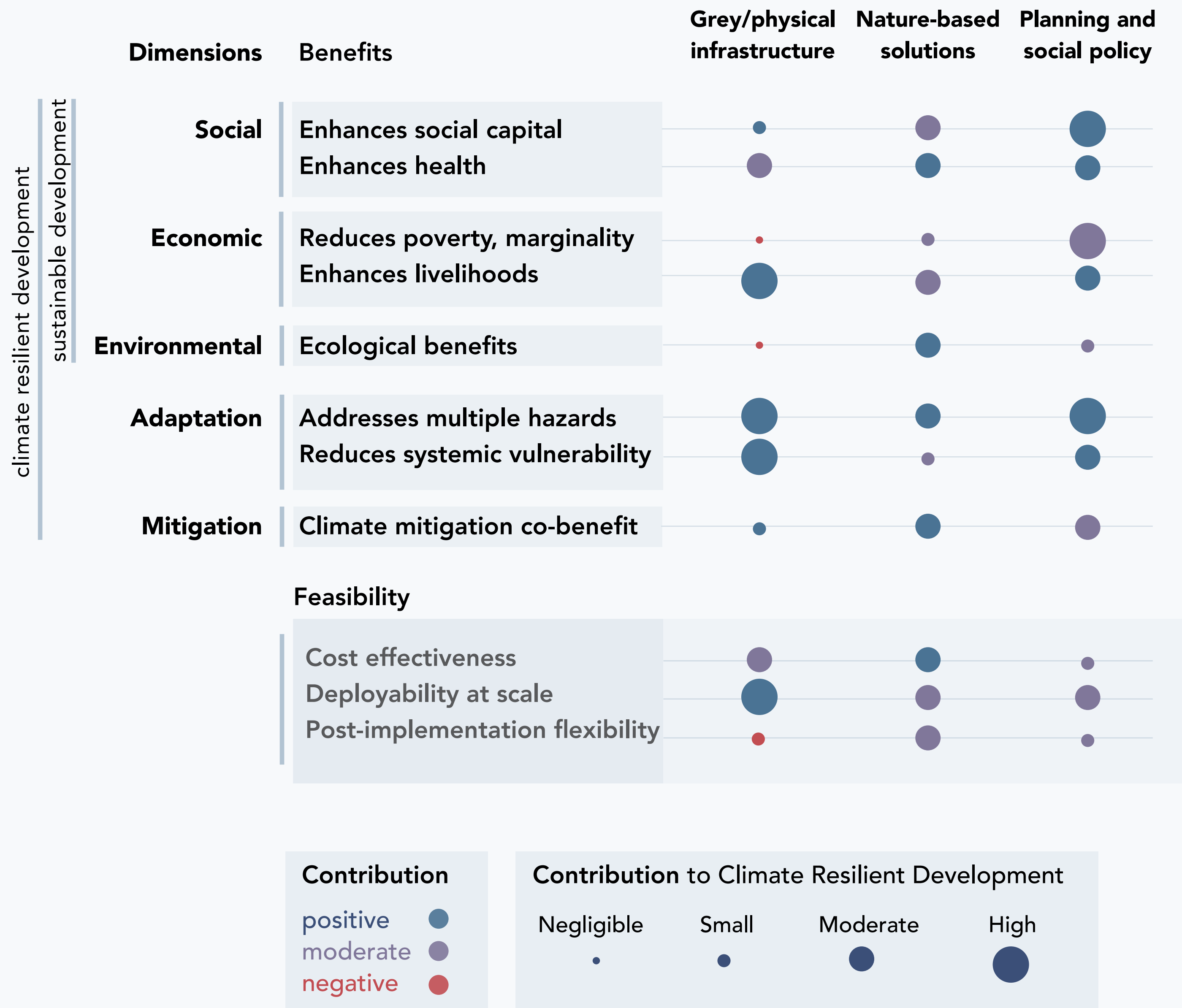
Figure 7 shows potential benefits of adaptation options fundamental to CRD. Physical infrastructure can provide resilience to a range of climate hazards, while providing notable co-benefits to livelihoods. However, notable challenges can limit the benefits of physical infrastructure: a lack of flexibility post-deployment; the transfer of risk to other people and places; and negative ecological impacts.

The integration of research, policy, and action to support CRD efforts remains the exception in most regions. Community-based adaptation planning and actions, with the potential to enhance well-being and advance the Sustainable Development Goals, provide one area of notable ongoing efforts. Complex trade-offs and gaps persist, including in the alignment of mitigation and adaptation efforts across geographic scale and policy areas.[81]

***Cities and urban areas offer critical spaces to realize adaptation and mitigation simultaneously with significant potential co-benefits, while also pre-empting potential trade-offs.***

*Sarajevo, Bosnia-Herzegovina*

**Figure 7: Contributions of urban adaptation options to Climate Resilient Development and their feasibility**




**Grey/physical Infrastructure** — Dikes, seawalls; water storage, greywater use; slope revetments; air conditioning; passive cooling; upgrading trasnport, energy, water & sanitation infrastructure; information & communication technologies; urban design & building regulations

**Nature-based solutions** — Urban agriculture; street trees; green roofs; parks and open spaces; community gardens; rain gardens; bioswales; retention ponds; riverbanks; floodplains and watershed restorations

**Planning and social policy** — Land use planning; social safety nets; emergency and disaster risk management; health services; climate education; heritage conservation

*Source: Derived from IPCC AR6 WGII Chapter 6, Figure TS.9(d)*

# 6. ENABLING CONDITIONS FOR URBAN CLIMATE ACTION

Enabling conditions play a critical role in determining the scalability and efficacy of climate responses. Such conditions promote or advance the adaptation process and are positively associated with the likelihood that strategies will be properly planned and put into practice. Crossover and connection exists between enabling conditions for climate adaptation and those for CRD, and for that matter, mitigation, as explored in SUP Volume 3.

Urban climate resilient development is enabled when governments, civil society, and the private sector, supported by science and the media, make inclusive development choices that prioritise risk reduction, equity, inclusion, and justice, and when decision-making processes, finance, and actions are integrated across governance levels, systems, and timeframes. This section identifies a set of enablers that are applicable to both climate adaptation and CRD, including: inclusive governance and institutional capacity, and political commitment; finance; monitoring and evaluation; technology and innovation; lifestyle and behaviour change including building climate literacy; and attention to culture and heritage.

*Singapore*

## Inclusive governance and institutional capacity

Inclusive governance of urban systems can improve opportunities for incremental adaptation and transformative change. Inclusive processes strengthen the ability of city governments and other stakeholders to jointly consider factors such as the rate and magnitude of change and uncertainties, associated impacts, and timescales of different pathways. Climate responses in all cities and urban areas can be enhanced by multi-level, multi-scalar, and multi-actor governance, with particular attention to the participation of the most vulnerable and marginalised groups. This is particularly true in many low-income countries where urban populations are expanding rapidly and city-scale governance is not yet well established.[82] A number of principles and lessons have been identified to address governance challenges and strengthen enablers. These include using an adaptation pathways approach to make short-term decisions consistent with long-term goals, and using inclusive planning processes that give voice to vulnerable people.[83] Urban governance for CRD is most effective when supported by formal and informal institutional capacities that are well-aligned across scales, sectors, policy domains and timeframes.

## Finance

Provided by national and subnational governments, finance is essential for many adaptation and mitigation interventions, as many such measures do not generate the direct returns on investment necessary to attract private finance. Considerable variation is present among national and city governments in terms of their public budgets and commensurate capacity to fund climate action. Looking beyond public expenditure to public revenues, a critical challenge for many city governments will be to climate-proof their budgets. Cities and urban areas that can demonstrate coherence in climate risk management across private and public actors may attract preferential access to finance.

Private finance for adaptation may be sourced from households' and firms' own resources, or from financial institutions such as commercial banks, investment companies, and pension funds.[84] Private finance from financial institutions can be directed towards CRD through, for example, spatial plans that encourage the construction of housing and infrastructure in areas that are less exposed to climate hazards as well as building regulations and codes that take account of future climate risks.[85] Private finance from the latter can be mobilised through dedicated financing instruments such as bank loans, bond issuance, public-private partnerships, and land value capture. In many cases, deploying these instruments will require the

***Climate responses in all cities can be enhanced by multi-level, multi-scalar and multi-actor governance, with particular attention to the participation of the most vulnerable, and marginalised groups.***

London, UK

use of public resources to ensure satisfactory risk-return ratios for private financiers, who rarely provide finance for adaptation on easier or cheaper terms than for other purposes. Many city governments do not have the authority to deploy all of these instruments, so mobilising private finance depends on effective multi-level governance.[86] Mobilising finance for the points of greatest social and ecological need, rather than to the points of greatest financial return, remains a challenge for the private sector.

Forging greater consensus on the financial implications associated with climate change risk remains an under-explored component of urban adaptation. Alignment of the capital allocations of cities, national governments, utilities, and the private sector can support risk avoidance in cities and urban areas where the finance and insurance sector have a presence. Where the insurance sector refuses to underwrite new developments within city-demarcated setback lines, or which vehicle insurance aligns with the phasing out of specific vehicle types, for example, rapid change becomes possible.

With higher warming comes greater risks and adaptation costs: the costs of adapting to 1.5°C is a fraction of the cost of adapting to 3°C. International, concessional climate finance is not keeping pace with rising adaptation costs, nor was it ever intended to cover the total financing needs for CRD. Urban policymakers therefore need to think holistically about possible financial resources from all public and private actors and from global to local scales.[87]

## Monitoring and evaluation

Monitoring and evaluation (M&E) of past adaptation and ongoing adaptation and CRD implementation can advance knowledge and enhance decision-making strategies by providing cities with knowledge regarding the progress and effectiveness of climate adaptation and mitigation action. Roughly one-third of countries have undertaken steps to develop national adaptation M&E systems, but fewer than half of these are reporting on implementation. Efforts to establish a single set of metrics and common and consistent reporting of local risk and adaptation implementation are increasingly sophisticated at the local level, particularly through global city networks tracking city-level commitments. Meaningful and continuous monitoring and evaluation can help provide insights into the role of local context in risk reduction and system-level transitions. Monitoring is critical to derive early warning signals on climatic hazards to assess when and where accelerated or adjusted action is needed. Data and information produced by monitoring and evaluation is especially important for policy makers and practitioners when arguing for or promoting new and aggressive action.[88]

## Technology and innovation

Technology and innovation, coupled with access to emerging actionable data, information, and enhanced decision-making capacity, are also critical to enhancing adaptation and CRD. New technologies and design innovations in urban transportation systems, for example, can enhance adaptation by strengthening

*Hangzhou, China*

capacity of existing road, rail, ports, and airports to withstand more extreme weather, while simultaneously delivering mitigation goals via reduced GHG emissions from the adoption of electric vehicles, car-sharing, and increased public transport use.[89] Other examples of existing technologies for adaptation in cities and urban areas include smart meters to monitor water use, technology-based service delivery, and embedded smart waste management.[90] In terms of climate mitigation, new decarbonisation technologies applied in energy, infrastructure, and industrial systems can facilitate and enable system transitions within cities and urban areas.[91]

## Lifestyle and behaviour change

Lifestyle and behaviour change is key to preparing for, and responding to, climate change.[92] Tools to incentivise adaptation behavior include: better information on climate impacts and risks to shape individual risk beliefs; zoning restrictions; building codes to guide climate resilient infrastructure development, and improving climate literacy.[93] Regulatory instruments, including tax and fiscal incentives for business and individuals, can support city-wide behavior change towards low-carbon and risk reducing choices.[94] Access to information is critical for adapting to climate risk and reducing vulnerability to hazards, yet access to this information is often not equally available. For example, low literacy can hamper ability to respond to early warning information.[95]

Overall, behavioural interventions are more readily taken up if they are aligned with cultural practices, norms, and beliefs; on temporal scales within peoples' planning horizons; and built upon relationships of trust and legitimacy.[96] The feasibility of adaptation strategies and interventions, especially those entailing changing behaviour and practices, is increased by recognising and incorporating peoples' values and beliefs and indigenous knowledge and local knowledge systems, as well as the voices of women and vulnerable groups.[97]

## Culture and heritage

Culture and heritage can offer sources of aspiration and ambition to respond to climate change amidst feelings of discomfort, loss of sense of place, displacement, and anxiety. The manner in which urban leaders engage and articulate climate risks and opportunities influence societies' capacity for change. Specific cultural and natural heritage sites can serve as physical, social, and psychological refuges for communities during and after climate impacts. Culture and heritage can be drivers for urban areas to undergo ecological transition, supported by ecosystem-based adaptation. This action can be strengthened by cultural practices that promote a circular economy, focus on multi-generational time horizons, imbue an ethic of stewardship and conservation, and encourage broader transformative changes associated with CRD.[98]

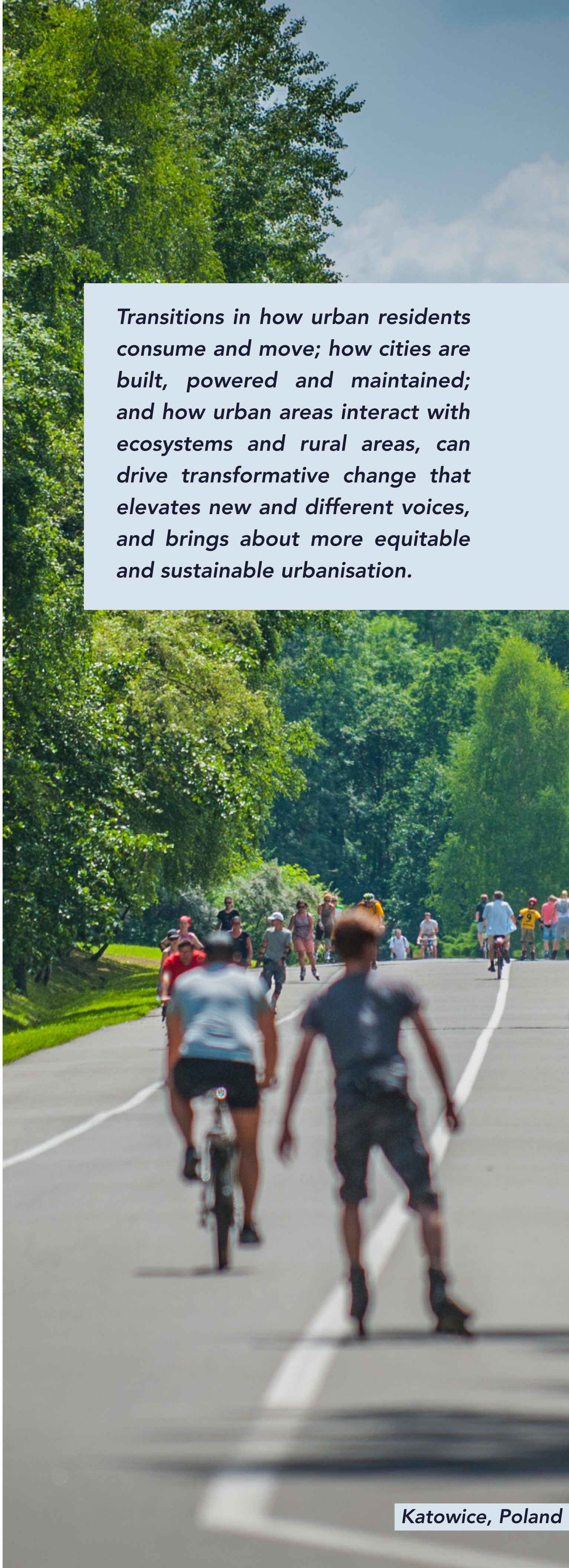

*Amsterdam, Netherlands*

# CONCLUSION: FROM TRANSITIONS TO TRANSFORMATION

The current opportunity to advance prosperity, human well-being, equity, and climate justice is significant. The continued warming of the planet, as well as associated extreme heat, drought, heavy rainfall, floods, storm surges, and cyclones, require immediate and extensive adaptation actions to make cities and urban areas more resilient. Yet the risks associated with climatic change are not borne evenly. They fall disproportionately on marginalised and vulnerable communities, exposing and deepening existing inequalities. Cities and urban areas have a central role to play in the systems transitions needed to adapt and mitigate, and, at the same time, to pursue climate resilient development that addresses inequality and promotes human well-being and ecosystem health. Some adaptation actions are needed immediately, while simultaneous system transitions and climate resilient development pathways offer a larger and long-term opportunity to move towards transformational action. Mitigation remains an essential precondition for the success of such effort, and a rapid reduction in GHG emissions remains the most effective way to reduce future risks.

Transitions in how urban residents consume and move; how cities are built, powered, and maintained; and interactions of urban areas with ecosystems and rural areas can power transformative change that elevates new and different voices while bringing about more equitable and sustainable political settlement. Such a renegotiation of the relationships between groups of people, between people and nature, and between people and the material world is required to meet the crises at hand.

***Transitions in how urban residents consume and move; how cities are built, powered and maintained; and how urban areas interact with ecosystems and rural areas, can drive transformative change that elevates new and different voices, and brings about more equitable and sustainable urbanisation.***



*Katowice, Poland*

# ANNEX

**Essential Principles and Concepts**

Clarity in some essential principles can further the understanding of current climate science and the development and implementation of associated policies.This annex provides IPCC definitions from Working Group II on concepts central to understanding, and taking action around, cities and climate change. So as to maintain consistency, these definitions, while shortened at times, are drawn directly from AR6 WGII.[99]

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

**Adaptation limits** are the point at which a system's needs or an actor's objectives cannot be secured from intolerable risks through adaptation actions.

**Climate justice** links sustainable development and human rights to achieve a rights-based approach to addressing climate change.

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

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

**Hazard** is the potential occurrence of a natural or human-induced physical event or trend 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.

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

**Losses and damages:** Lowercase letters (losses and damages) refer broadly to harm from (observed) impacts and (projected) risks and can be economic or noneconomic; Loss and Damage (capitalised letters) to refer to political debate under the United Nations Framework Convention on Climate Change (UNFCCC) following the establishment of the Warsaw Mechanism on Loss and Damage in 2013.

**Maladaptation** is actions that lead to increased risk of adverse climate-related outcomes, including via increased GHG emissions, increased or shifted climate vulnerability, more inequitable outcomes, or diminished welfare, now or in the future. Maladaptation is most often an unintended consequence.

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

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

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

**Social infrastructure** is the social, cultural and financial activities and institutions as well as associated property, buildings and artefacts and policy domains such as social protection, health and education that support well-being and public life

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

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

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# ENDNOTES

[1] As the AR6 cycle moved from the Special Reports and Working Group I to Working Groups II and III, a fifth systems transition,societal transition, was added to the four originally described in the Special report on 1.5oC of global warming.
[2] IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Summary for Policymakers, Executive Summary
[3] Ibid., Technical Summary, TS.C.5.4; Cross-Chapter Paper 2, CCP2.2
[4] Ibid., Technical Summary, TS.B.8.1
[5] Ibid., Chapter 6, Executive Summary; Summary for Policymakers, Section D
[6] Ibid., Chapter 6, 6.3.2, 6.3.3, 6.3.4
[7] Ibid., Summary for Policymakers, Section A
[8] Ibid., Technical Summary, Figure TS.13; Chapter 1, 1.3.1
[9] Ibid., Summary for Policymakers, Section A
[10] Ibid., Summary for Policymakers, B.5.4
[11] Ibid., Cross-Chapter Paper 2, CCP2.2
[12] Ibid., Chapter 6, Executive Summary
[13] Ibid., Chapter 6, 6.1.4
[14] Ibid., Chapter 10, 10.4.6
[15] Ibid., Chapter 12, 12.3.7
[16] Ibid., Chapter 13, 13.6.1
[17] Ibid., Chapter 14, 14.5.5
[18] Ibid., Chapter 6, 6.2; Chapter 16, 16.5.2
[19] Ibid., Summary for Policymakers, B.3
[20] Ibid., Chapter 6, Executive Summary
[21] Ibid., Chapter 7, Executive Summary, 7.3.1
[22] Ibid., Cross-Chapter Paper 2, Figure CCP2.3
[23] Ibid., Summary for Policymakers, B.4.5
[24] Ibid., Summary for Policymakers, B.4.7
[25] IPCC, 2021: Summary for Policymakers, B.5.4. In: ***Climate Change 2021: The Physical Science Basis***. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001; IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Chapter 13, 13.10.2; Cross-Paper Chapter 2, CCP2.2
[26] IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Chapter 6, 6.2.4
[27] Ibid., Chapter 6, Executive Summary; Chapter 9, Box 9.1; Chapter 10, Executive Summary; Chapter 12, 12.5.7; Chapter 18, Cross-Chapter Box GENDER | Gender, Climate Justice and Transformative Pathways
[28] Ibid., Chapter 8, 8.4.5; Chapter 9, 9.9.3; Chapter 10, 10.4.6; Chapter 11, 11.3.5; Chapter 12, Fig. 12.7, 12.3.2; Chapter 13, 13.6; Chapter 14, 14.5.3
[29] Ibid., Chapter 8, 8.3.4, Box 8.5, Box 8.6; Chapter 9, 9.9.4, 9.9.5; Chapter 10, 10.4.6; Chapter 12, 12.5.7
[30] IPCC, 2021: ***Climate Change 2021: The Physical Science Basis***. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896
[31] IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Summary for Policymakers
[32] Ibid., Chapter 6, Executive Summary; Chapter 10, 10.4.6; Chapter 12, 12.5.5
[33] Ibid., Chapter 18, 18.4
[34] Ibid., Chapter 10, 10.4.6
[35] Ibid., Chapter 14, Box 14.4, 14.5.5
[36] Ibid., Chapter 9, 9.9.5
[37] Ibid., Chapter 9, 9.9.5, Figure 9.31
[38] Ibid., Chapter 12, Executive Summary, 12.5.5, 12.5.7
[39] Ibid., Chapter 13, 13.6.2
[40] Ibid., Chapter 6, 6.3.2
[41] Ibid., Chapter 6, 6.4.2, Table 6.7
[42] Ibid., Chapter 12, 12.5.5 and 12.5.7
[43] Ibid., Summary for Policymakers, C.2, C.3
[44] Ibid., Chapter 16, 16.4.3
[45] Ibid., Cross-Chapter Paper 2, CCP2.3; Ibid., Chapter 10, 10.4.6
[46] Ibid., Chapter 6, 6.4.4
[47] Ibid., Chapter 6, 6.4.6; Chapter 12, 12.7.2
[48] Ibid., Chapter 6, 6.4.1
[49] Ibid., Chapter 6, 6.4.1; 6.4.3, 6.4.4, 6.4.7, Box 6.6; Chapter 18, Cross-Chapter Box GENDER | Gender, Climate Justice and Transformative Pathways
[50] Ibid., Chapter 6, 6.4.1, 6.4.3, 6.4.6, 6.4.7; Chapter 10, 10.4.6; Chapter 16, 16.3.3; Chapter 17, 17.5.2
[51] Ibid., Chapter 12, 12.5.5
[52] IPCC, 2022. ***Climate Change 2022: Mitigation of Climate Change***, Technical Summary TS5.2; Chapter 8, Executive Summary; IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Chapter 6, 6.3.5
[53] IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Cross-Chapter Paper 2, CCP2.3; Chapter 17, Cross Chapter Box DEEP | Effective adaptation and decision-making under deep uncertainties

[54] Ibid., Cross-Chapter Paper 2, CCP2.3; Chapter 3, Cross-Chapter Box SLR | Sea Level Rise
[55] Ibid., Chapter 6, 6.3.5
[56] Ibid., Chapter 6, Executive Summary
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[58] Ibid., Chapter 9, 9.9.1; Chapter 12, 12.5.5
[59] Ibid., Chapter 10, 10.4.6
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[61] Ibid., Summary for Policymakers, C.2.7
[62] IPCC, 2022: Annex II: Glossary [Möller, V., et al. (eds.)]. In: ***Climate Change 2022: Impacts, Adaptation and Vulnerability***. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029.
[63] IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Chapter 2, Executive Summary
[64] Ibid., Chapter 13, 13.6.2; Chapter 6, 6.3.2, 6.3.4
[65] Ibid., Chapter 6, 6.3.4
[66] Ibid., Chapter 6, 6.3.4; Cross-Chapter Paper 2, CCP2.3
[67] Ibid., Chapter 2, Cross-Chapter Box NATURAL | Nature-Based Solutions for Climate Change Mitigation and Adaptation; Chapter 6, 6.3.4; Chapter 10, FAQ 10.4; Chapter 13, Executive Summary
[68] Ibid., Chapter 13, Executive Summary
[69] Ibid., Cross-Chapter Paper 2, CCP2.3
[70] Ibid., Chapter 6, 6.3.4
[71] Ibid., Chapter 6, 6.2.6
[72] Ibid., Chapter 2, Executive Summary
[73] Ibid., Chapter 12, 12.5.6
[74] Ibid., Chapter 18, Cross-Chapter Box INDIG | The Role of Indigenous Knowledge and Local Knowledge in Understanding and Adapting to Climate Change
[75] Ibid., Summary for Policymakers, Figure SPM.5, C.2.11, C.2.13; Chapter 6, 6.3.3
[76] Ibid., Chapter 6, 6.4.1
[77] Ibid., Chapter 6, 6.4.7
[78] Ibid., Chapter 6, Cross-Working-Group Box URBAN: Cities and Climate Change
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[80] IPCC, 2022. ***Climate Change 2022: Impacts, Adaptation and Vulnerability***, Chapter 6, Cross-Working-Group Box URBAN: Cities and Climate Change
[81] Ibid., Chapter 6, Executive Summary
[82] Ibid., Technical Summary, TS.E.2.6
[83] Ibid., Summary for Policymakers, C.5.1
[84] Ibid., Chapter 6, 6.4.5
[85] Ibid., Chapter 1, 1.4.4; Chapter 6, 6.3.3
[86] Ibid., Chapter 6, 6.4.5
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[89] Ibid., Chapter 6, 6.3.5
[90] Ibid., Chapter 10, 10.4.6
[91] Ibid., Chapter 18, Table 18.3
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[95] Ibid., Chapter 6, 6.3.6
[96] Ibid., Cross-Chapter Paper 2, CCP2.4.1
[97] Ibid., Cross-Chapter Paper 2, CCP2.4.1; Chapter 6, 6.1.4
[98] Ibid., Chapter 2, 2.6.5; Chapter 3, Table 3.25, 3.6.3; Chapter 6, 6.1.5, 6.2.6, 6.3.3; Chapter 8, 8.4.5; Chapter 9, 9.11.4, 9.12.1, 9.12.3; Chapter 11, Table 11.11; Chapter 13, Box 13.1, 13.8.1; Chapter 15, 15.3.4, 15.6.5
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VOLUME II

WHAT THE LATEST SCIENCE ONIMPACTS, ADAPTATION AND VULNERABILITY MEANS FOR CITIES AND URBAN AREAS

SUMMARY FOR URBAN POLICYMAKERS