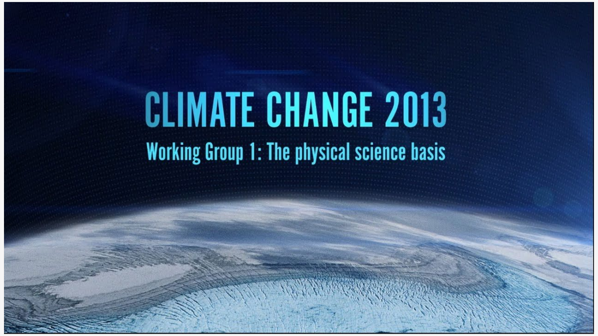
23-24 October 2023
Symposium on Climate Change
Tokyo, Japan

INTERGOVERNMENTAL PANEL ON climate change
ipcc
WMO UNEP

Cities and Climate Change: From AR6 to AR7

Winston CHOW
Co-Chair, Working Group II (WGII), IPCC AR7
Lead Author, WGII, IPCC AR6

“Urban” before AR6; in AR5



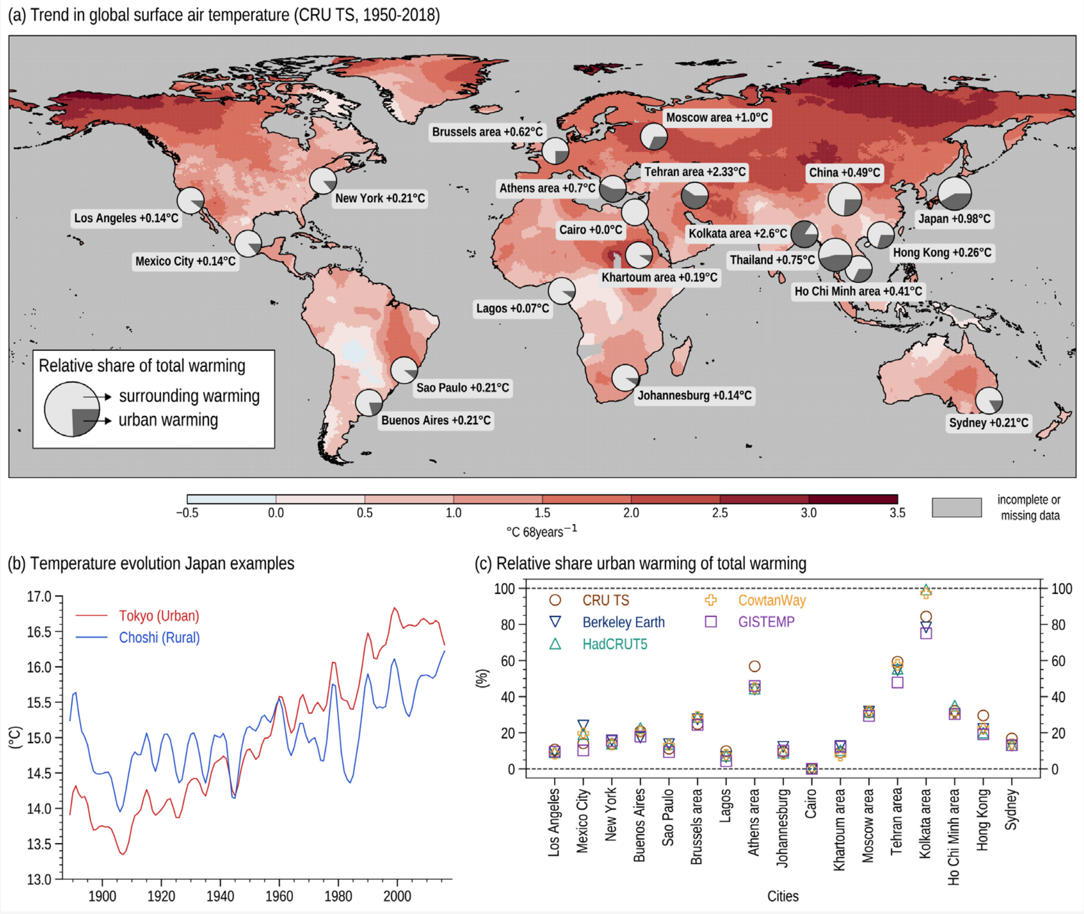
WG I – single mention on urban albedo and two mentions of heat islands with reference to Global Mean Surface Temperatures

Three chapters in WGII on "Human Settlements, Industry, and Infrastructure”, include one dedicated chapter on “Urban Areas”

Human settlements, infrastructure and spatial planning chapter in WGIII, and several implicitly urban sectoral chapters

AR6 “urban” material

- **WGI**
  - Chapter 10: Linking Global to Regional Climate Change
  - Influence of heat islands and temperature extremes



The difference in observed warming trends between cities and their surroundings can partly be attributed to urbanization (*very high confidence*).

Annual-mean daily minimum temperature is more affected by urbanization than annual-mean daily maximum temperature (*very high confidence*).

Urbanization has exacerbated changes in temperature extremes in cities, in particular for nighttime extremes (*high confidence*)

AR6 “urban” material

Box 10.3 | Urban Climate: Processes and Trends

Urban areas have special interactions with the climate system that produce heat islands. This box presents information about these processes, how they are parametrized in climate modules, and on the role of urban monitoring networks. A discussion on the observed climate trends and climate change projections for urban areas follows.

Urban heat island

During nighttime, urban centres are often several degrees warmer than the surrounding rural area, a phenomenon known as the nighttime canopy urban heat island effect (Bader et al., 2018; Kuang, 2019; Li et al., 2019; Y. Li et al., 2020a). While green and blue infrastructures can mitigate the urban heat island effect, three main factors contribute to its development (Hamdi et al., 2020; Masson et al., 2020): (i) three-dimensional urban geometry including building density and plan area, street aspect ratio and building height; (ii) thermal characteristics of impervious surfaces; and (iii) anthropogenic heat release, either from building energy consumption, especially waste heat from air conditioning systems, or as direct emissions from industry, traffic, or human metabolism (Ichinose et al., 1999; Sailor, 2011; de Munck et al., 2013; Bohnenstengel et al., 2014; Chow et al., 2014; Salamanca et al., 2014; Dou and Miao, 2017; Ma et al., 2017a; Chrysoulakis et al., 2018; Takane et al., 2019). Urban heat island magnitude is also affected by aerosols due to air pollution in urban areas (Cheng et al., 2020; Han et al., 2020) and by local background climate (Zhao et al., 2014; Ward et al., 2016).

Monitoring network

Long-term climate datasets (a year or more) at the small spatial scales required to resolve processes of interest for cities (<1 km) are scarce (Bader et al., 2018; Caluwaerts et al., 2020). Moreover, urban observation sites often represent only parts of the urban environment and are suboptimal for detecting urban effects (e.g., sites in city parks). Recently, city-scale climate monitoring networks as well as satellite and ground-based remote sensing are being used (though still missing in Global South cities; Technical Annex I), enhancing our understanding of the urban microclimate and its interaction with climate change, and providing key information for users (F. Chen et al., 2012; Barlow et al., 2017; Bader et al., 2018). It has been found that harmonization of collection practices, instrumentation, station locations, and quality control methodologies across urban environments needs improvement to facilitate collaborative research (Muller et al., 2013; Barlow et al., 2017). Real time crowdsourcing data is becoming available (Section 10.2.4). The urban climate community is making efforts to understand how these methods can complement traditional datasets (Meier et al., 2017; Zheng et al., 2018; Langendijk et al., 2019b; Venter et al., 2020).

Urban modules in climate models

Exchanges of heat, water and momentum between the urban surface and its overlying atmosphere are calculated using specific surface-atmosphere exchange schemes. Three different schemes, here in order of increasing complexity, can be distinguished (Masson, 2006; Grimmond et al., 2010, 2011; Chen et al., 2011; Best and Grimmond, 2015): (i) in the slab or bulk approach, the three-dimensional city structure is not resolved but cities are represented by modifying soil and vegetation parameters within land surface models, increasing roughness length and displacement height (e.g., Seaman et al., 1989; Dandou et al., 2005; Best et al., 2006; Liu et al., 2006). The energy balance is often modified to account for the radiation trapped by the urban canopy, heat storage, evaporation and anthropogenic heat fluxes. (ii) Single-layer urban canopy modules use a simplified geometry (urban canyon, with three surface types: roof, road and wall) that approximately capture the three-dimensional dynamical and thermal physical processes influencing radiative and energy fluxes (Masson, 2000; Kusaka et al., 2001). (iii) Multi-layer urban canopy modules compute urban effects vertically, allowing a direct interaction with the planetary boundary layer (Brown, 2000; Martilli et al., 2002; Hagishima et al., 2005; Dupont and Mestayer, 2006; Hamdi and Masson, 2008; Schubert et al., 2012). Building-energy models that estimate anthropogenic heat from a building for given atmospheric conditions can be incorporated. Recent model development has focused on improving the representation of urban vegetation (Lee et al., 2016; Redon et al., 2017; Mussetti et al., 2020).

Global (McCarthy et al., 2010; Oleson et al., 2011; Zhang et al., 2013; H. Chen et al., 2016; Katzfey et al., 2020; Sharma et al., 2020; Hertwig et al., 2021) and regional modelling groups (Oleson et al., 2011; Kusaka et al., 2012a; McCarthy et al., 2012; Hamdi et al., 2014; Trusilova et al., 2016; Daniel et al., 2019; Halenka et al., 2019; Langendijk et al., 2019a) are beginning to implement these urban parametrizations within the land surface component of their models. There is *very high confidence* (*robust evidence* and *high agreement*) that while all types of urban parametrizations generally simulate radiation exchanges in a realistic way, they have strong biases when simulating latent heat fluxes, though recent research incorporating in-canyon vegetation processes improved their performance. There is *medium confidence* (*medium evidence*, *high agreement*) (Kusaka et al., 2012b; McCarthy et al., 2012; Hamdi et al., 2014; Trusilova et al., 2016; Jänicke et al., 2017; Daniel et al., 2019) that a simple single-layer parametrization, is sufficient for the correct simulation of the urban heat island magnitude and its interplay with regional climate change.

- Box 10.3 Urban climates – processes and trends
  - Including assessment of regional climate projections and need for high spatial resolution projections

AR6 “urban” material

- **WGII**
  - Chapter 6 and regional chapters
  - Cross-Chapter Paper on coastal cities
    - Especially on issues of sea level rise and adaptation approaches to reduce risk

Projected number of people at risk of a 100-year coastal flood.

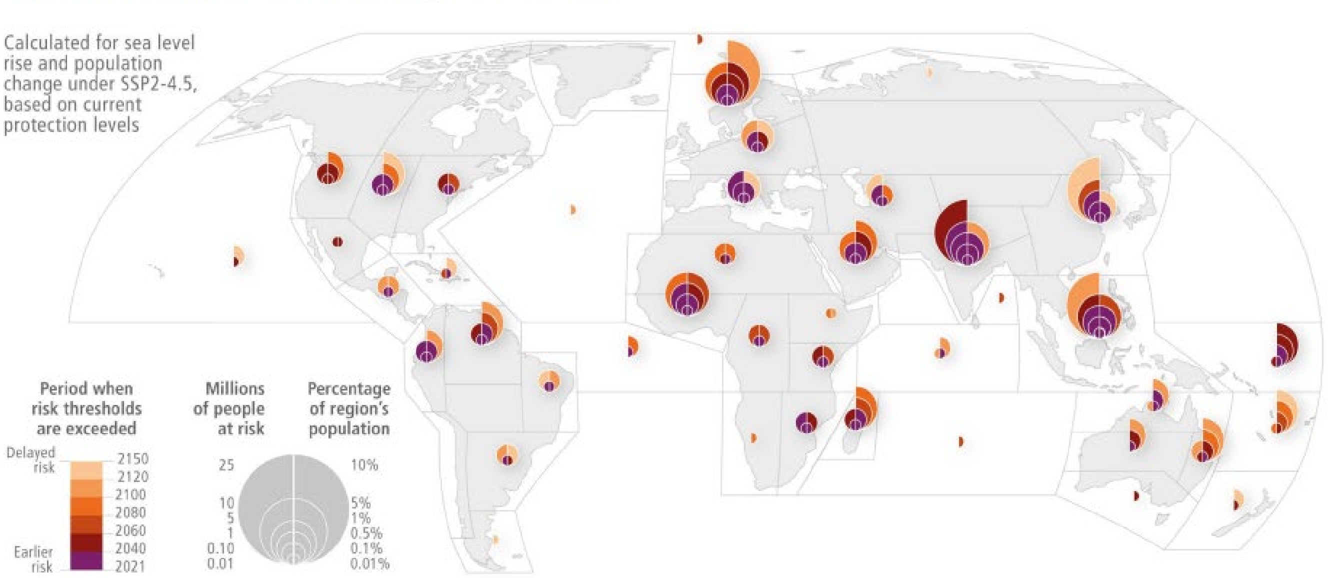
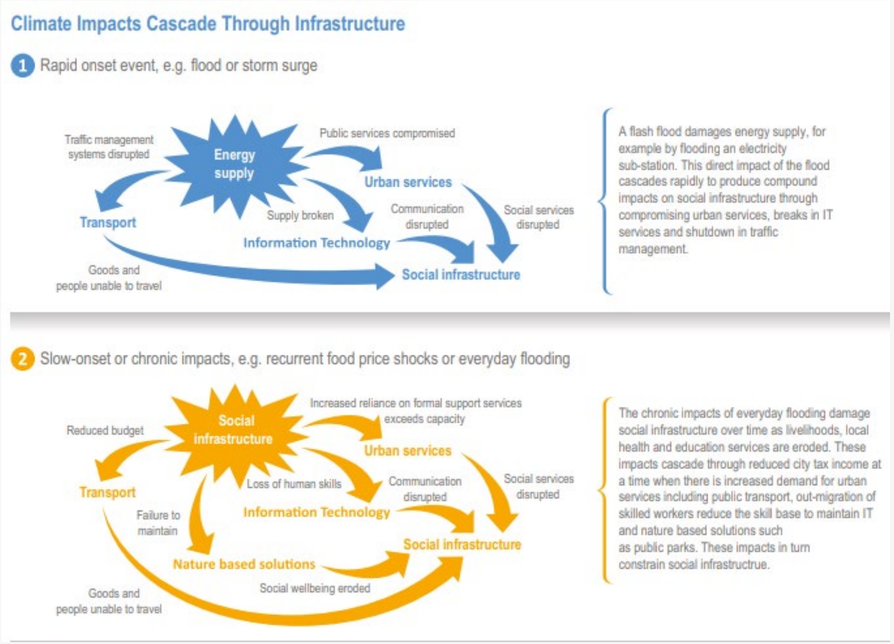


Figure 1: The size of the circle represents the number of people at risk per IPCC region and the colours show the timing of risk based on projected population change and sea level rise under SSP2-4.5*. Darker colours indicate earlier in setting risks. The left side of the circles shows absolute projected population at risk and the right side the share of the population in percentage. {Figure TS.9c}.

AR6 “urban” material



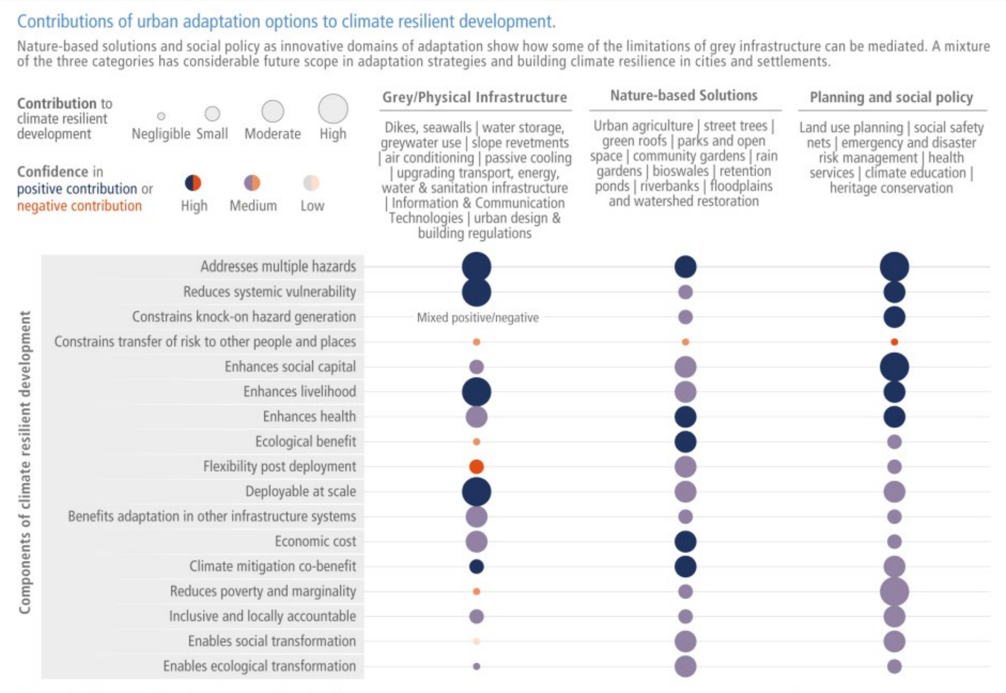


Figure 2: The figure is based on Table 6.6 which is an assessment of 21 urban adaptation mechanisms. Supplementary Material 6.3 provides a detailed analysis including definitions for each component of climate resilient development and the evidences. {Figure TS.9d}

WGII

- Compound & cascading risks
- Adaptation & climate resilient development

AR6 "urban" material

- **WGIII**
  - Chapter 8: Urban systems and Other Settlements
  - Other sectoral chapters – Buildings, Transport, and Industry
  - WGII and III also had a shared cross-WG box on cities and climate change

Cross-Working Group Box 2: Cities and Climate Change

Authors: Xuemei Bai (Australia), Vanesa Castán Broto (Spain/United Kingdom), Winston Chow (Singapore), Felix Creutzig (Germany), David Dodman (Jamaica/United Kingdom), Rafiq Hamdi (Belgium), Bronwyn Hayward (New Zealand), Şiir Kılkış (Turkey), Shuaib Lwasa (Uganda), Timon McPhearson (the United States of America), Minal Pathak (India), Mark Pelling (United Kingdom), Diana Reckien (Germany), Karen C. Seto (the United States of America), Ayyoob Sharifi (Iran/Japan), Diana Ürge-Vorsatz (Hungary)

Introduction

This Cross-Working Group Box on Cities and Climate Change responds to the critical role of urbanisation as a megatrend impacting climate adaptation and mitigation. Issues associated with cities and urbanisation are covered in substantial depth within all three Working Groups (including WGI Box TS.14, WGII Chapter 6 'Cities, Settlements and Key Infrastructure', WGII regional chapters, WGII Cross-Chapter Paper 'Cities and Settlements by the Sea', and WGIII Chapter 8 'Urban Systems and Other Settlements'). This Box highlights key findings from WGII and III and substantial gaps in literature where more research is urgently needed relating to policy action in cities. It describes methods of addressing mitigation and adaptation in an integrated way across sectors and cities to advance sustainable development and equity outcomes and assesses the governance and finance solutions required to support climate-resilient responses.

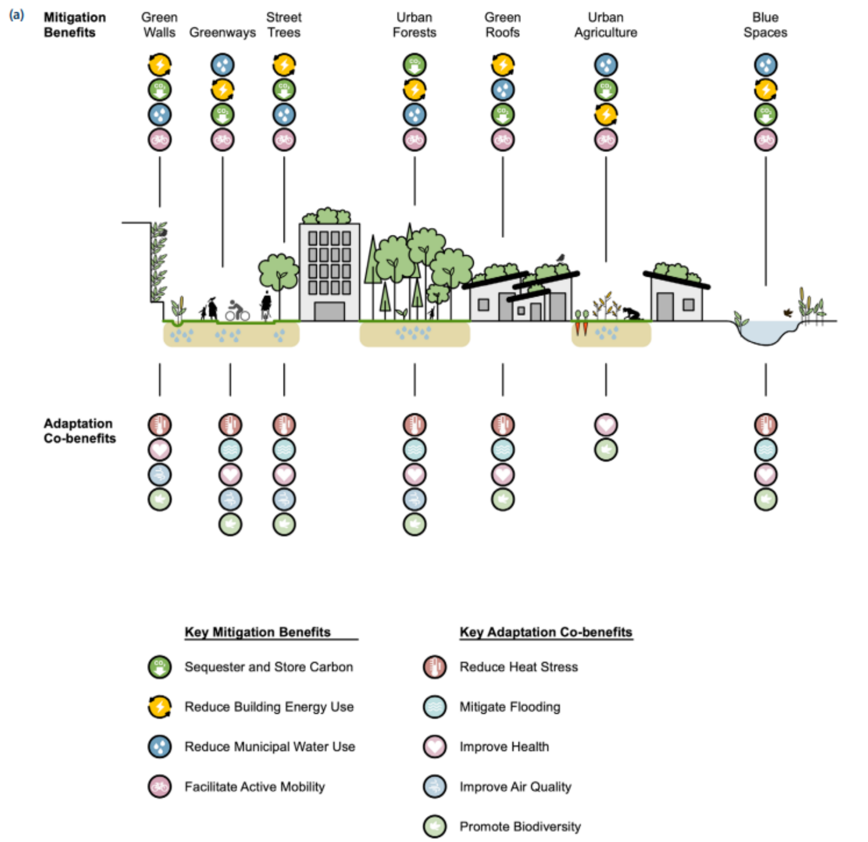
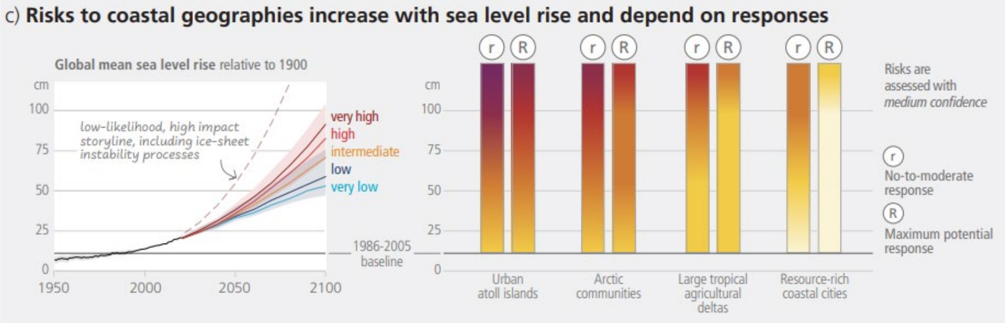
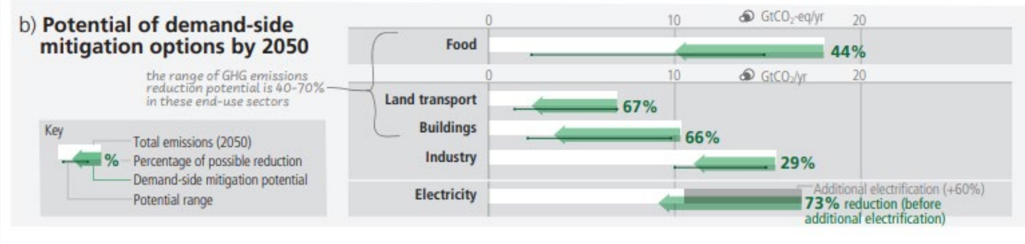


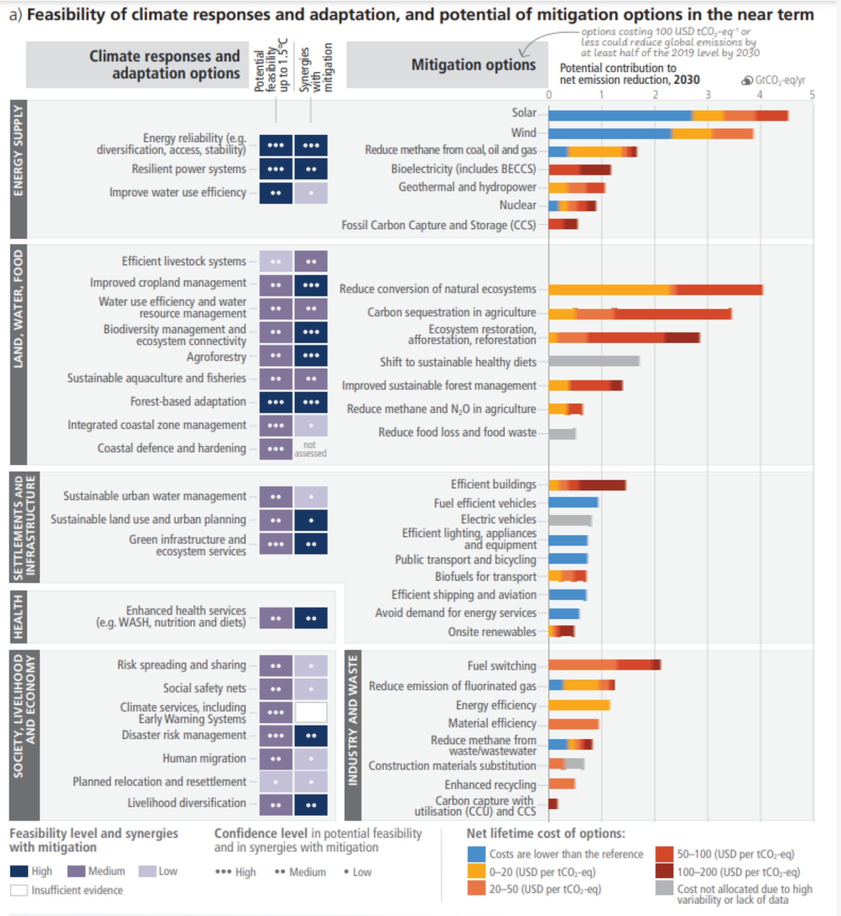
Figure 8.18: Key mitigation benefits, adaptation co-benefits, and SDG linkages of urban green and blue infrastructure. Panel (a) illustrates the potential integration of various green and blue infrastructure strategies within an urban system.

AR6 “urban” material

- **Synthesis Report**
  - 18 mentions of “urban” in SPM text in terms of higher risks but also as avenues of climate action through climate resilient development







From AR6 to AR7

Special Report on Climate Change and Cities (Decided in P-43)

- Supported by Governments & UN-Habitat, C40 cities, ICLEI, UCLGs, GCOM…
- Significant interest from practitioner, decision-making, and advocacy communities
- Involves contributions from all Working Groups, and will administratively be led by one Working Group (TBD) for the 7th Assessment Cycle

SR-Cities projected timeline

Scoping meeting (early-mid 2024)

Scoping experts with relevant urban expertise will be invited to attend

Consideration of representation from different regions & from different sectors

Scoping involves designing the chapter framework & relevant topics

Scientific Steering Committee will have oversight

Approval at IPCC Plenary (late 2024)

Feedback from governments on the chapter scoping & narrative

Approval of SR outline leads to author invitation & selection process

Author invitation & selection process and workplan for SR-Cities TBD after Plenary

What do authors do?

Attend Author meetings and develop drafts

Review of drafts from expert reviewers, review editors & governments

Final government draft & summary for policymakers

Approval Plenary

Estimated timeframe 2-3 years

What is needed?

Note when the call for nomination comes out

Ask your government focal point or recognised scientific agencies for nomination

Expertise is important BUT regional representation is critical for a comprehensive assessment

Thank you!

@IPCC_CH
#IPCCReport

@IPCC

@IPCC

linkedin.com/
company/ipcc

For more information: IPCC Secretariat: ipcc-sec@wmo.int IPCC Press Office: ipcc-media@wmo.int Visit ipcc.ch