

work closely with the local research institution, the Sierra Leone Urban Research Centre (SLURC). SLURC has played an essential role in curating spaces for continuous learning and relationship-building between FEDURP and community residents, including the formation of 'Community Learning Platforms' (CLP) for mixed groups of community actors (City Learning Platform, 2019) to build their capacities to address climate risk collectively. This is done by drawing on the data, agency and mobilisation potential of community organisations in informal settlements. In the coastal settlement of Cockle Bay at the western end of the city, uncontrolled traditional land reclamation ('banking') along the shores progressively exposed residents to perennial floods from tidal surges, and the settlement received regular threats of evictions from city authorities. However, residents have drawn on their climate risk knowledge and hazard profiling to self-manage a process of action planning resulting in a decision to prohibit further land reclamation. It also identified and demarcated an exterior boundary of the settlement and planned and constructed new drainage channels to carry away runoff water within the community (Allen et al., 2017). The community organisations have subsequently successfully negotiated with the

Ministry of Environment to formalise this new exterior boundary, which has led to the authorities dropping their threats of evictions.

The approach taken in Freetown demonstrates a pathway to adaptation that is based on a more people-centred approach to urban planning that understands the aspirations of urban residents, addresses climate risk and advances sustainable development (Woodcraft et al., 2020; Fraser et al., 2017). It further provides an example of the ways in which different sources and scales of data can be co-produced (Kovacic et al., 2019) and targeted interventions can be co-designed with community residents (Musango et al., 2020). The community-generated data on climate and health risks and the subsequent strategic action plans developed through local community organisations' work have been recognised and incorporated into a new city-wide initiative led by the Office of the Mayor, dubbed Transform Freetown (Allen et al., 2020a). The action has expanded the political space for the urban poor's collectives to strategically engage in urban resilience planning, highlighting the value and potential of participatory processes and community-generated data.

Cross-Working-Group Box URBAN | Cities and Climate Change

Authors: Xuemei Bai (Australia), Vanesa Castán Broto (UK/Spain), Winston Chow (Singapore), Felix Creutzig (Germany), David Dodman (Jamaica/UK), Rafiq Hamdi (Belgium), Bronwyn Hayward (New Zealand), Şiir Kılıç (Turkey), Shuaib Lwasa (Uganda), Timon McPhearson (USA), Minal Pathak (India), Mark Pelling (UK), Diana Reckien (Germany), Karen Seto (USA), Ayyoob Sharifi (Japan/Iran), Diána Ürges-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'; WGIII Chapter 8 'Urban systems and other settlements'). This Box highlights key findings from Working Groups II 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.

Urbanisation: A Megatrend Driving Global Climate Risk and Potential for Low-Carbon and Resilient Futures

Severe weather events, exacerbated by anthropogenic emissions, are already having devastating impacts on people who live in urban areas, and on the infrastructure that supports these communities and those of many other distant places (*high confidence*) (Cai et al., 2019; Folke et al., 2021). Between 2000 and 2015, the global population in locations that were affected by floods grew by 58–86 million (Tellman et al., 2021). The direct economic costs of all extreme events reached USD 210–268 billion in 2020 (Aon, 2021) or about USD 0.7 billion d⁻¹; this figure does not include knock-on costs in supply chains or days off work lost so that the actual economic costs could be far higher. Depending on RCP, between half (RCP2.6) and three-quarters (RCP8.5) of the global population could be exposed to periods of life-threatening climatic conditions arising from coupled impacts of extreme heat and humidity by 2100 (see Section 6.2.2.1; WGII Figure 6.3; Mora et al., 2017; Zhao et al., 2021; Huang et al., 2019).

The interdependencies between infrastructure, services and networks driven by urban production and consumption mean that urban systems are now global; remittance flows and investments reach into rural places shaping natural resource use far from the city and bring risk to the city when these places are impacted by climate change. This urbanisation megatrend (Kourtit, Nijkamp and Scholten, 2015) amplifies and shapes the potential impacts of climate events. It provides the economic and institutional framework for integrating the aims and approaches that can deliver mitigation, adaptation and sustainable development (*medium evidence, high agreement*) (Zscheischler et al., 2018; Dawson et al., 2018; Tsavdaroglou et al., 2018). For cities facing flood damage, wide-ranging impacts have been recorded on other urban areas (Simpson et al., 2021; Carter et al., 2021) as production and trade is disrupted (Shughrue et al., 2020).

Cross-Working Group Box (continued)

In the absence of integrated mitigation and adaptation across and between infrastructure systems and local places, impacts that bring urban economies to a standstill can extend into supply chains or across energy networks causing power outages.

Urban settlements are drivers of climate change, generating about 70% of global CO₂-eq emissions (*high confidence*) (WGI Box TS.14; WGIII 8 ES; WGII 6.1, WGII 6.2). This global impact feeds back to cities through the exposure of infrastructure, people and business to the impacts of climate-related hazards. Especially in the larger cities, this climate feedback is exacerbated by local choices in urban design, land use, building design and human behaviour (Viguié et al., 2020) that shape local environmental conditions. Local and global conditions influence the nature of hazards in urban centres: urban form can add up to 2°C to warming, concretisation of open space can increase runoff and building height and orientation influences wind direction and strength (WGII 6.3).

Building today for resilience and lower emissions is far easier than retrofitting tomorrow. As urbanisation unfolds, its legacy continues to be the locking in of emissions and vulnerabilities (*high confidence*) (Ürge-Vorsatz et al., 2018; Seto et al., 2016). Retrofitting, disaster reconstruction and urban regeneration programmes offer scope for strategic direction changes to low-carbon and high-resilience urban form and function if they are inclusive in design and implementation. Rapid urban growth means new investment, new buildings and infrastructure, new demands for energy and transport and new questions about what a healthy and fulfilling urban life can be. The USD 90 trillion expected to be invested in new urban development by 2030 (NCE, 2018), is a global opportunity to place adaptation and mitigation directly into urban infrastructure and planning, and social policy including education and health care and environmental management (Ürge-Vorsatz et al., 2018). If this opportunity is missed, if business as usual urbanisation persists, then social and physical vulnerability will be not be so easily confronted.

The benefits of actions taken to reduce greenhouse gas (GHG) emissions and climate stressors diminish with delayed action, indicating the necessity for rapid responses. Delaying the same actions for increasing the resilience of infrastructure from 2020 to 2030 is estimated to have a median cost of at least USD 1 trillion (Hallegatte et al., 2019), while also missing the carbon emissions reductions required in the narrowing window of opportunity to limit global warming to 1.5°C (WGI). In contrast, taking integrated actions toward mitigation, adaptation and sustainable development will provide multiple benefits for the health and well-being of urban inhabitants and avoid stranded assets (WGII 6.3, WGII 17; WGIII 5; WGIII 8.2; Cross-Chapter Box FEASIB in Chapter 18).

The Policy-Action Gap: Urban Low-Carbon and Climate Resilient Development

Cities are critical places to realise actions on both adaptation and mitigation simultaneously, with potential co-benefits that extend far beyond cities (*medium evidence, high agreement*) (Grafakos et al., 2020; Göpfert, Wamsler and Lang, 2019). Given rapid changes in the built environment, transforming the use of materials and the land intensiveness of urban development including in many parts of the Global South in the next decades will be critical, as well as mainstreaming low-carbon development principles in new urban development in all regions. Much of this development will be self-built and 'informal', and new modes of governance and planning will be required to engage with this. Integrating mitigation and adaptation now rather than later, through reshaping patterns of urban development and associated decision making processes, is a prerequisite for attaining resilient and zero carbon cities.

While more cities have developed plans for climate adaptation and mitigation since AR5, many remain to be implemented (*limited evidence, high agreement*) (Araos et al., 2017; Olazabal and De Gopegui, 2021; Aguiar et al., 2018). A review of local climate mitigation and adaptation plans across 885 urban areas of the European Union suggests mitigation plans are more common than adaptation plans, and that city size, national legislation and international networks can influence the development of local climate plans with an estimated 80% of cities with above 500,000 inhabitants having a mitigation and/or an adaptation plan (Reckien et al., 2018b).

Integrated approaches to tackle common drivers of emissions and cascading risks provide the basis for strengthening synergies across mitigation and adaptation, and managing possible trade-offs with sustainable development (*limited evidence, medium agreement*) (Grafakos et al., 2019; Landauer, Juhola and Klein, 2019). Analysis of 315 local authority emission reduction plans across the European Union reveals that the most common policies cover municipal assets and structures (Palermo et al. 2020). Estimates of emission reductions by non-state and sub-state actors in 10 high-emitting economies projected GHG emissions in 2030 would be 1.2–2.0 GtCO₂-eq per year or 3.8–5.5% lower compared to scenario projections for current national policies (31.6–36.8 GtCO₂-eq per year) if the policies are fully implemented and do not change the pace of action elsewhere (Kuramochi et al. 2020). The value of integrating mitigation and adaptation is underscored in the opportunities for decarbonising existing urban areas, and investing in social, ecological and technological infrastructure resilience (WGII 6.4). Integrating mitigation and adaptation is challenging (Landauer, Juhola and Klein, 2019) but can provide multiple benefits for the health and well-being of urban inhabitants (Sharifi, 2020).

Cross-Working Group Box (continued)

Effective climate strategies combine mitigation and adaptation responses, including through linking adaptive urban land use with GHG emission reductions (*medium evidence, high agreement*) (Xu et al., 2019; Patterson et al., 2021). For example, urban green and blue infrastructure can provide co-benefits for mitigation and adaptation (Ürge-Vorsatz et al., 2018) and is an important entry point for integrating adaptation and mitigation at the urban level (Frantzeskaki et al., 2019). Grey and physical infrastructure such as sea defences can immediately reduce risk, but can also transfer risk and limit future options. Social policy interventions including social safety nets provide financial security for the most at risk and can manage vulnerability determined both by specific hazards and independently. Hazard-independent mechanisms for vulnerability reduction, such as population-wide social security, provide resilience in the face of unanticipated cascading impacts or surprise and novel climate-related hazard exposure. Social interventions can also support, or be led by, ambitions to reach the Sustainable Development Goals (Archer, 2016). Climate resilient development invites planners to plan interventions and monitor the effectiveness of outcomes beyond individual projects and across wider remits that reach into sustainable development. Curbing the emission impacts of urban activities to reach net zero in the next decades while improving the resilience of urban areas necessitates an integrated response now.

Key gaps in knowledge include urban enabling environment; how smaller settlements, low-income communities living in slums and informal settlements, but also those in rental housing spread across the city, and actions to reduce supply chain risk can be supported to accelerate equitable and sustainable adaptation in the face of financial and governance constraints (Birkmann et al., 2016; Shi et al., 2016; Dulal, 2019; Rosenzweig et al., 2018b).

Enabling Action

Innovative governance and finance solutions are required to manage complex and interconnected risks across essential key infrastructures, networks and services and meet basic human needs in urban areas (*medium confidence*) (Moser et al., 2019; Colenbrander, Dodman and Mitlin, 2018). There are many examples of 'ready-to-use' policy tools, technologies and practical interventions for policymakers seeking to act on adaptation and mitigation (Keenan, Chu and Peterson, 2019; Bisaro and Hinkel, 2018; Chirambo, 2021). Tax and fiscal incentives for business and individuals can help support city-wide change behaviour toward low carbon and risk reducing choices. Change can start where governments have most control; in public sector institutions and investment, but the challenge ahead requires partnership with private sector and community actors acting at scale and with accountability. Urban climate governance and finance needs to address urban inequalities at the forefront if the urban opportunity is to realise the ambition of the Sustainable Development Goals.

Increasing investment at pace will put pressure on governance capability and transparency and accountability of decision making (*medium confidence*) (WG II 6.6.4.5). Urban climate action that actively includes local actors and is built on an evidence base open to independent scrutiny is more likely to avoid unintended, negative maladaptive impacts and mobilise a wide range of local capacities. In the long run, this is also more likely to carry public support, even if some experiments and investments do not deliver the intended social benefits. Legislation, technical capacity and governance capability is required to be able to absorb additional finance. About USD 384 billion yr⁻¹ of climate finance has been invested in urban areas in recent years. This remains at about 10% of the annual climate finance that would be necessary for low-carbon and resilient urban development (Negreiros et al., 2021). Rapid deployment of funds to stimulate economies in recovery from COVID-19 have highlighted the pitfalls of funding expansion ahead of policy innovation and capacity building. The result can be an intensification of existing urban forms, exactly the kinds of choices and preferences that contribute to risk creation and its concentration among those with little public voice or economic power.

Iterative and experimental approaches to climate adaptation and mitigation decision making co-generated in partnership with communities, can advance climate-resilient decarbonisation (*medium evidence, high agreement*) (Caldarice, Tollin and Pizzorni, 2021; Culwick et al., 2019; van der Heijden and Hong, 2021). Conditions of complexity, uncertainty and constrained resources require innovative solutions which are both adaptive and anticipatory. Complex interactions among multiple agents in times of uncertainty makes decision making about social, economic, governance, and infrastructure choices challenges, and can lead decision makers to postpone action. This is the case for those balancing household budgets, residential investment portfolios and city-wide policy responsibilities. Living with climate change requires changes to business-as-usual design making. Co-design and collaboration with communities through iterative policy experimentation can point the way toward CRD pathways (Ataöv and Peker, 2021). Key to successful learning is transparency in policymaking, inclusive policy processes and robust local modelling, monitoring and evaluation, which are not yet widely undertaken (Ford et al., 2019; Sanchez Rodriguez, Ürge-Vorsatz and Barau, 2018).

The diversity of cities' experiences of climate mitigation and adaptation strategies brings an advantage for those city government and other actors willing to 'learn together' (*limited evidence, high agreement*) (Bellinson and Chu, 2019; Haupt and Coppola, 2019). While contexts are varied, policy options are often similar enough for the sharing of experiments and policy champions. Sharing expertise can

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build on existing regional and global networks, many of which have already placed knowledge, learning and capacity building at the centre of their agendas. Learning from innovative forms of governance and financial investment, and strengthening co-production of policy through inclusive access to knowledge and resources, can help address mismatches in local capacities, strengthen wider Sustainable Development Goals and COVID-19 Recovery agendas (*limited evidence, medium agreement*). Perceptions of risk can greatly influence the reallocation of capital and shift financial resources (Battiston et al., 2021). Coupling mitigation and adaptation in an integrated approach offers opportunities to enhance efficiency, increases the coherence of urban climate action, generates cost savings and provides opportunities to reinvest the savings into new climate action projects to make all urban areas and regions more resilient.

Local governments play an important role in driving climate action across mitigation and adaptation as managers of assets, regulators, mobilisers and catalysts of action, but few cities are undertaking transformative climate adaptation or mitigation actions (*limited evidence, medium agreement*) (Heikkinen, Ylä-Anttila and Juhola, 2019). Local actors are providers of infrastructure and services, regulators of zoning, and can be conveners and champions of an integrated approach for mitigation and adaptation at multiple levels (*limited evidence, high confidence*). New opportunities in governance and finance can enable cities to pool resources together and aggregate interventions to innovate ways of mobilising urban climate finance at scale (White and Wahbah, 2019; Simpson et al., 2019; Colenbrander, Dodman and Mitlin, 2018). However, research increasingly points toward the difficulties faced during the implementation of climate financing *in situ*, such as the fragmentation of structures of governance capable of managing large investments effectively (Mohammed et al., 2019).

Scaling up transformative place-based action for both adaptation and mitigation requires enabling conditions including land-based financing, intermediaries and local partnerships (*medium evidence, high agreement*) (Tirumala and Tiwari, 2021;). Governance structures that combine actors working at different levels with different mixes of tools are effective in addressing challenges related to implementation of integrated action, while cross-sectoral coordination is necessary (Singh et al., 2020). Joint institutionalisation of mitigation and adaptation in local governance structures can also enable integrated action (Göpfert et al., 2020; Hurlimann et al., 2021). However, the proportion of international finance that reaches local recipients remains low, despite the repeated focus of climate policy on place-based adaptation and mitigation (Manuamorn, 2019). Green financing instruments that enable local climate action without exacerbating current forms of inequality can jointly address mitigation, adaptation and sustainable development. Climate finance that also reaches beyond non-state enterprises, including SMEs, communities and NGOs, and is responsive to the needs of urban inhabitants, including disabled individuals and different races or ethnicities, is essential for inclusive and resilient urban development (Colenbrander, Dodman and Mitlin, 2018; Frenova, 2020). Developing networks that can exert climate action at scale is another priority for climate finance.

The urbanisation megatrend is an opportunity to transition global society. Enabling urban governance to avert cascading risk and achieve low-carbon, resilient development will involve co-production of policy and planning, rapid implementation and greater cross-sector coordination, monitoring and evaluation (*limited evidence, medium agreement*) (Grafakos et al., 2019; Di Giulio et al., 2018). New constellations of responsible actors are required to manage hybrid local-city or cross-city risk management and decarbonisation initiatives (*limited evidence, medium agreement*). These may increasingly benefit from linkages across more urban and more rural space as recognition of cascading and systemic risk brings recognition of supply chains, remittance flows and migration trends as vectors of risk and resilience. Urban governance will be better prepared in planning, prioritising and financing the kind of measures that can reduce GHG emissions and improve resilience at scale and pace when considering a view of cascading risks and carbon lock-ins globally, while acting locally to address local limitations and capacities, including the needs and priorities of urban citizens (Colenbrander, Dodman and Mitlin, 2018).