Urban Climate Resilience and Its Link to Global Sustainability Agendas

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Abstract

This chapter examines urban climate resilience. It provides a conceptual introduction, followed by an explanation of how urban areas have been recognized in recent global agendas related to sustainability, climate change, and disaster risk reduction. The chapter provides a picture of the complexity and diversity of urban climate resilience experiences, through seven case study cities on four continents. The sample of cities includes small, medium, and larger cities, both coastal and landlocked, in diverse political, socioeconomic, and geographical contexts. Drawing on comparative research using co-production between academic researchers and local authority counterparts, the detailed case studies illustrate the climate resilience challenges faced by each city, the work in terms of strategies and initiatives they have carried out and are planning to increase their resilience, as well as the geographical and policy contexts in which those strategies are embedded.

Keywords

Climate resilience · Urban resilience · Cities · Vulnerability · Climate adaptation · Climate change · Global environmental change · Agenda 2030 · Urban sustainability

1 Introduction

Resilience can be broadly understood as an ability to withstand shocks and stresses and to adjust and adapt to changing conditions (such as climate/environmental change) (UNISDR 2015a). Particularly when including measures to reduce poverty, vulnerability, and inequality, resilience is sometimes referred to as "bouncing back better." Resilience itself is one dimension of sustainability, that broader concept of

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long-term, non-destructive, and ideally enhanced viability and maintenance of resources. General treatments of resilience are often implicitly aspatial. In this chapter, the focus is on urban areas as subnational concentrations of population and economic activities with specific built environments. Hence, a spatial lens is essential because of the differential ways in which resilience or its inadequacy finds expression in and through these environments, mediated by complex multi-scalar forces and processes.

In promoting urban sustainability and resilience, it is essential to address the challenges posed by climate change from different angles, by reducing exposure to hazards and limiting the underlying conditions that make populations particularly vulnerable to those hazards. The former relates to addressing the increasing frequency and probably severity of extreme events (IPCC 2012) as well as the gradual change in underlying conditions such as sea-level rise (IPCC 2014a, 2018). The latter relates to the importance of integrating into the resilience work the challenge of insidious, daily risks and hazards faced particularly by poor and marginalized urban residents, who frequently have very different perceptions and priorities from professionals and elites (Ensor et al. 2014; Manda and Wanda 2017; Simon 2012; Simon and Leck 2013, 2014; Ziervogel et al. 2017). Similarly, economic globalization under conditions of relatively open borders and mobile speculative and investment capital poses great risks in relation to technological change, fluctuations in labor costs and regulatory regimes, and economic restructuring. The resilience challenges posed by rapid deindustrialization, for instance, in a city like Malmö in southern Sweden, one of the case studies in this chapter, were profound.

There are other dimensions too. Hence, a comprehensive urban resilience framework is essential – as pioneered by the Rockefeller Foundation 100 Resilient Cities (100 RC) program, comprising four principal dimensions (Rockefeller Foundation and Arup 2015). Application of this framework was made more tangible through development of a purpose-designed and comprehensive City Resilience Index (CRI) comprising 12 goals and 52 indicators (Rockefeller Foundation and Arup 2018) – see Fig. 1. How this worked in practice, and how participating cities engaged with the global Sustainable Development Goals, launched simultaneously, has not yet been fully analyzed, although Buenos Aires and Cape Town (see section ▶ "Buenos Aires, Argentina and Cape Town, South Africa"), two of the 100 RC cities that are also part of the sample examined here, provide some reflections and lessons learned (e.g., Croese et al. 2020). The City Resilience Index has also been applied to Shimla (see section "Shimla, India"). **With the broader conceptualization of resilience in mind, the focus of this chapter is particularly on the resilience (or lack thereof) of urban areas to climate variability and change**, with recognition of the dynamics between global environmental change and other social and economic processes.

It is now widely recognized by the international community that current forms of urbanism and processes of urbanization are almost invariably unsustainable and insufficiently resilient to deal with the unprecedented changes to prevailing conditions. Urban areas and urban-related terms therefore emerge as watchwords of major reports from the Intergovernmental Panel on Climate Change (IPCC 2014b, esp. Chapter 8, 2018) and the Second Assessment Report of the Urban Climate Change

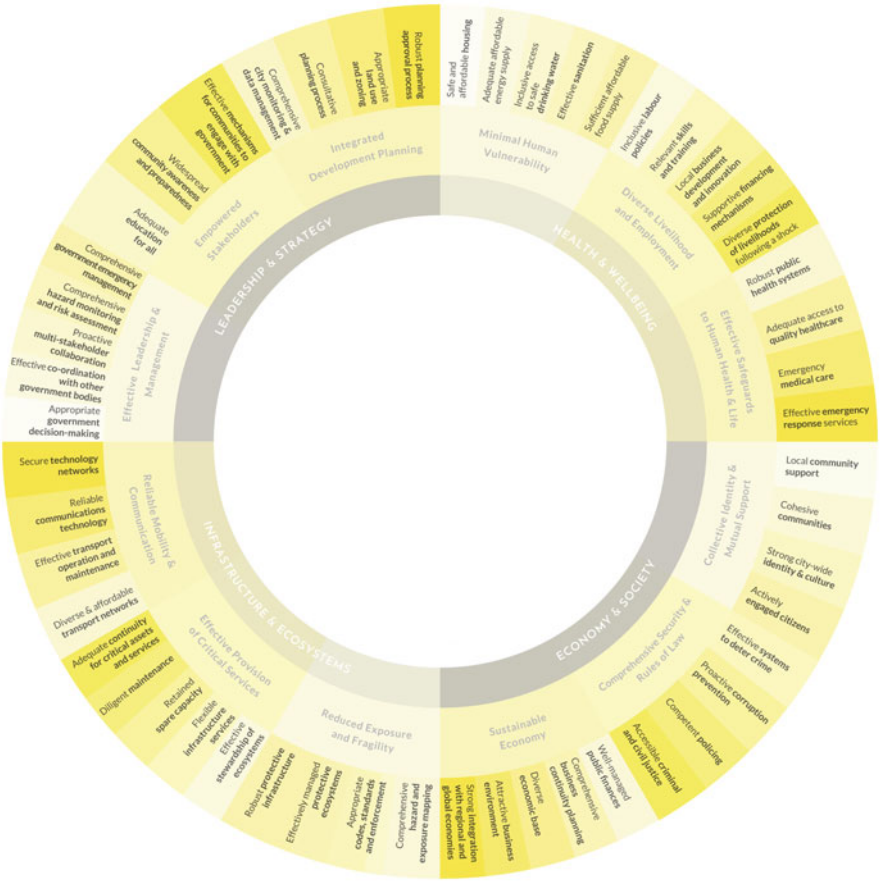

Fig. 1 The City Resilience Index. (Source: Rockefeller Foundation and Arup 2018, p. 17)

Research Network (UCCRN) (Rosenzweig et al. 2018). Indeed, two of the five "pathways to urban transformation" that the latter report identifies focus on resilience, namely, the need to reduce greenhouse gas (GHG) emissions while increasing resilience and the centrality of disaster risk reduction and climate change adaptation to urban resilience. The precise combinations of risks vary, principally between coastal and inland localities and by agroecological zone, as will be exemplified later in this chapter.

Our urban focus does not regard urban areas as discrete entities but as integral parts of broader territorial, political, and functional urban regions. These frequently comprise multiple local authorities and other bodies responsible for particular functions or services, each constrained by politico-administrative boundaries.

Many key forces and processes are transboundary in nature, such as economic globalization and climate/environmental change, and even basic urban functions such as the supply of water, food, and building materials, and the removal and safe

disposal or recycling of waste. Hence no individual local authority or utility corporation can on its own ensure substantive resilience. Instead, effective collaborative transboundary governance is required, both horizontally (i.e., among neighboring authorities in the relevant functional region) and vertically (i.e., together with regional, national, and possibly international authorities and nongovernmental actors). As recent evidence shows, however (e.g., IPCC 2018; Leck and Simon 2018; Rosenzweig et al. 2018), this is hard to achieve in practice, and successful examples are limited in number and scope outside a handful of well-resourced metropolitan regions of the Global North. Inevitably, most analysis (e.g., Reckien et al. 2018), including in relation to the examples cited here, therefore relates to the extent to which individual municipalities have engaged with and implemented sustainability and resilience strategies.

Although the focus of attention in terms of climate change mitigation, adaptation, and transformative strategies and actions to address them is on intermediate and large cities, it is important to consider urban areas of all sizes, since even small towns can have major greenhouse gas (GHG) point sources. Small and intermediate urban areas as a category are also often growing faster in relative terms than many large cities and, particularly in the Global South, are predicted to be the fastest-growing categories over the next few decades (UN-HABITAT 2016).

In the next section, we explain how urban areas have been incorporated explicitly for the first time in new global sustainable development agendas. In Sect. "3" we present case studies of urban resilience drawn from seven cities. The selected cities were part of a comparative and transdisciplinary international research project that took place between 2017 and 2020 under the umbrella of the Mistra Urban Futures transdisciplinary research institute and its research partners in the case study cities (Valencia et al. 2019, 2020). The case studies are then discussed and conclusions are drawn in Sect. "4".

2 Urban Areas in Global Agendas

2015 and 2016 represented a remarkable and unprecedented watershed in the history of the United Nations as national governments adopted five landmark agreements on different aspects of sustainability that all recognized explicitly for the first time the essential role of "subnational entities" in achieving their objectives. This is the UN terminology for all forms of regional and local authorities, the latter including, of course, urban municipalities. More remarkably, the last of the agreements to be adopted, namely, the New Urban Agenda in late 2016, is solely about urban areas and urbanization – itself a reflection of the implications of *Homo sapiens* now being a predominantly urban species.

The Sendai Framework on Disaster Risk Reduction and the Paris Agreement on Climate Change address the global challenges introduced in Sect. "1" above and which represent profound challenges to urban areas and all that is bound up with them. Para 19f of the Sendai Framework explicitly mentions the necessity of empowering local authorities and communities for disaster risk reduction (DRR)

through resources, incentives, and decision-making responsibilities (UNISDR 2015a). The Paris Agreement refers to climate change as a global challenge at all levels, including local (Article 7(2)), and climate adaptation and promotion of climate resilience as a key objective at all levels (Article 2(1)b) (UNFCCC 2016). Resilience is mentioned only in passing a few times. Agenda 2030 for Sustainable Development is one of the latest global commitments in a process dating back at least to the World Conference on Environment and Development in 1992. For present purposes, the key element is its set of 17 Sustainable Development Goals (SDGs), intended to encapsulate the complexity and multifaceted nature of sustainable development with its three dimensions (social, environmental, and economic) and on which all UN member governments have to report progress annually (United Nations 2015). This is a major and symbolically important change compared to their predecessor the Millennium Development Goals (MDGs), which ran from 2000 to 2015, applied only to low- and lower middle-income countries, and included only eight goals.

Crucially, Goal 11 focuses specifically on sustainable cities and communities and, together with the relevant urban elements of the other SDGs, forms a key focus of the remainder of this chapter. Goal 11 addresses urban resilience in two of its targets, as follows:

- "11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations"
- "11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels" (United Nations 2015)

Goal 13 on climate change focuses on strengthening resilience, arguably at all levels, including through planning, education, and awareness raising. Various targets in other goals could also contribute to urban resilience, even when this is not explicitly mentioned, such as the targets that promote education and healthy living as well as upgrading education facilities and energy infrastructure, for example (UNISDR 2015b). Target 1.5, under Goal 1, which is about reducing poverty in all its forms, focuses on building the resilience of the poor and those in vulnerable situations to climate-related extreme events and other economic, social, and environmental shocks and disasters.

The other targets within Goal 11 which deal with issues of housing, transportation, environmental pollution and waste management, green and public spaces, and supporting positive links between urban, peri-urban, and rural areas could all be directly or indirectly linked to resilience through both potential synergies and trade-offs. Several targets could contribute to resilience efforts if potential interactions

(in the forms of synergies and trade-offs) are considered and planned for (UNISDR 2015b). For instance, efforts to increase access to adequate, safe, and affordable housing (target 11.1) through new developments need to consider changing environmental conditions to ensure that housing is resilient to potential environmental hazards today and in the future. As shown below in the case of Gothenburg, (see section "3.3 Gothenburg, Sweden") new housing developments near the river are being designed to face potential future sea-level rise and increasing rainfall due to climate change.

The New Urban Agenda also makes explicit reference to climate change and resilience: "We envisage cities and human settlements that: (g) adopt and implement disaster risk reduction and management, reduce vulnerability, build resilience and responsiveness to natural and man-made hazards, and foster mitigation and adaptation to climate change" (United Nations General Assembly 2016). "Environmentally Sustainable and Resilient Urban Development" is one of the three "Transformative Commitments" made under the Implementation Plan for the New Urban Agenda. The declared vision of urban resilience is followed up in the agenda with implementation strategies that explicitly refer to planning approaches and policies that address climate change facilitated through means of implementation where climate finance is earmarked (UN-HABITAT 2019).

3 Case Studies of Urban Resilience

Here we present case studies describing the main risks that seven cities around the world are facing, and may face, due to climate change, as well as how these cities are working to increase their resilience. The sample of cities covers small- to medium-sized cities in all continents apart from North America and Oceania. The different sizes, locations, hazards exposed to, socioeconomic conditions, and institutional capacities of the cities provide a diversity of experiences and approaches. In this chapter, we use "City" (with uppercase "C") to denote the municipal organization as such, while "city" (with lowercase "c") denotes the physical urban settlement area plus its inhabitants and other constituent stakeholders (including the City).

3.1 Buenos Aires, Argentina

In Buenos Aires, Argentina, neighborhoods located in the basins of the 11 streams that traverse the city have historically been affected by flooding. Today, nearly 70% of the city's population lives in one of those basins, with estimates suggesting that 25% of the population is vulnerable to extreme events (Gobierno de la Ciudad de Buenos Aires 2018). In the process of urbanization, most of the streambeds were modified, and their original drainage systems were replaced by pipelines. These works were not carried out to improve runoff, but rather had an aesthetic purpose. These infrastructural developments, combined with increasing water flow rates and rainfall frequency in recent years, have increased the risk of flooding. Accordingly,

the City prepared a "Plan of assistance for the management of flood risk for the City of Buenos Aires," which, in recent decades, has included the development of a series of hydraulic works to reduce the risk and the impact of flooding in three of the major basins (the Maldonado, Cildáñez, and Vega streams).

With the exception of these infrastructural projects, the city has lacked a tradition of public policies specifically aimed at the prevention and mitigation of disaster risk. This has begun to change with the Resilience Strategy, which was launched in October 2018 and developed by the General Directorate of Strategic Management (DGGE, for its acronym in Spanish), which is part of the Department of Strategic Management and Institutional Quality (SSGEyCI) of the Buenos Aires City Government.

The resilience strategy was driven by the incorporation of Buenos Aires into the Rockefeller Foundation 100 Resilient Cities (100 RC) program in 2016 – see above. This initiative, created by the Rockefeller Foundation, supported cities to design, implement, and manage proactive solutions to address, among others, the challenges posed by urbanization, globalization, and climate change. In this context, the DGGE created the Buenos Aires Resilience Programme that operates as an Inter-ministerial Resilience Committee composed of representatives of all the ministries of the municipal government (Gobierno de la Ciudad de Buenos Aires 2017a, b).

From a comprehensive conception of the notion of resilience adopted by the City, which states that "urban resilience is the ability of individuals, communities, institutions, companies and systems that make up a city, to survive, adapt and get strengthened, independent of the acute impacts or chronic tensions to those that are exposed" (Gobierno de la Ciudad de Buenos Aires 2017c), the DGGE assessed the actions that are being developed to build the resilience of the city as well as evaluated the perceptions of different civil society actors. This assessment resulted in the identification of four key emerging issues, (1) green city, (2) integrated city, (3) city of opportunities, and (4) safe city, as well as three cross-cutting themes, (1) metropolitan perspective, (2) citizenship participation, and (3) digital city. The resilience strategy is structured around these cross-cutting themes and on five pillars: (1) diversity, gender, and coexistence; (2) innovation, talent, and opportunities; (3) environment and sustainability; (4) social and urban integration; and (5) security and risk management (Gobierno de la Ciudad de Buenos Aires 2018).

The last pillar refers specifically to climate resilience and has among its objectives to promote an informed, prepared, and aware citizenship; prepare the city to cope with the impacts of climate change; and promote innovation and technology to build safer spaces. These challenges are linked to 5 of the 17 Sustainable Development Goals (SDGs): SDG 4 about quality education; SDG 9 about industry, innovation, and infrastructure; SDG 11 about sustainable cities and communities; SDG 13 about climate action; and SDG 16 about peace, justice, and strong institutions (Gobierno de la Ciudad de Buenos Aires 2018).

As mentioned above, the greatest hazard for Buenos Aires is flood risk. For this reason, beyond the infrastructural projects undertaken by the City Government in the framework of the Hydraulic Plan (signed as Decree 695 in 2009), which defines the protocols of the Emergency Master Plan for 21 hazards, including rainfall and

consequent flooding, the City has undertaken awareness-raising activities with residents to raise their knowledge and preparedness for these risks. Furthermore, to anticipate emergencies, the city has put in place a storm alert system in order to prepare for extreme weather events. Finally, for the purpose of coordinating emergency officials and residents in disruptive situations, the Centre for Coordination and Control was created (Gobierno de la Ciudad de Buenos Aires 2018).

Both joining the 100 RC initiative and the commitments assumed under the SDG umbrella have become fundamental stimuli for the development of the Buenos Aires Resilience Strategy. Thereby the city has also been able to contribute with its local experience and participate in a global discussion on how to build more sustainable cities, with social and economic development and environmental balance.

3.2 Cape Town, South Africa

Between 2015 and 2019, Cape Town experienced the most intense and prolonged drought in its recorded history, culminating in the threat of "day zero," when the city would effectively run out of usable water. Climate change has increased the likelihood of more frequent and intense droughts in the future (Otto et al. 2018). In addition to a significant decrease in average rainfall, as well as a shift in the seasonality of rainfall, Cape Town is at risk from a range of other climate hazards, such as increasing temperatures, increasing wind speeds, increased fire risk, and increased sea-level rise and coastal erosion, with all of these hazards increasing in severity over time (Petrie et al. 2019).

Cape Town has several vulnerabilities that increase its climate-related risks. The primary vulnerability is low levels of adaptive capacity among its residents due to high levels of poverty, low-income levels, a significant proportion of people living in informal or substandard dwellings, as well as ongoing social stresses such as unemployment, crime, and poor health. This means that many residents are largely unable to protect themselves from climate hazards and are reliant on public sector institutions or nongovernmental organizations to undertake or assist with most adaptation measures.

Cape Town also has a number of physical vulnerabilities, many of which are related to a history of urban development in areas of risk. Many low-lying parts of the city have poor drainage and high water tables, increasing the risk of flooding even during normal winter rainfall events. With a coastline of over 300 km and much existing urban development close to the shore, the city is also at significant risk from coastal climate hazards, such as sea-level rise, coastal erosion, and storm surge and associated groundwater salinization. The city is also vulnerable to heat: although much of the city is relatively low density, many parts of the city lack trees and other green vegetation, exacerbating the urban heat island effect. Additionally, as with many cities in the Global South, Cape Town faces the challenge of implementing climate resilience measures on a limited budget and with constrained institutional resources (IPCC 2012).

In 2017, the City of Cape Town adopted a climate change policy which set out the City's approach to both adaptation and mitigation (City of Cape Town 2017). This policy was reviewed in 2019 and as of 2021 is undergoing conversion to a high-level climate change strategy (City of Cape Town 2020). Resilience is a core principle of both the 2017 policy and the new strategy and forms the guiding principle of the City's climate change response work.

Prior to the adoption of the policy, the City of Cape Town had focused on a sectoral approach to climate change resilience and adaptation and had addressed mitigation and adaptation in separate plans. However, following a review during 2019, the City determined that in order to more effectively address resilience, a consolidated and cross-cutting climate change action plan was required, incorporating both adaptation and mitigation and taking a thematic rather than sectoral approach. In doing so, the City of Cape Town has recognized that resilience is a cross-cutting issue that requires the cooperation of multiple City departments within thematic areas. The plan also recognizes that resilience goes beyond climate adaptation and acknowledges the role of mitigation actions in building resilience to energy shocks and stresses, as well as the co-benefits of actions that address both mitigation and adaptation.

The City's climate change work also intersects with its broader resilience work. As part of Cape Town's membership in the (former) Rockefeller Foundation 100 RC program, a preliminary resilience assessment was conducted using the 100 RC methodology, leading to the development of a Cape Town Resilience Strategy (City of Cape Town 2019). This strategy incorporates responses to climate change shocks and stresses but also looks more broadly at other non-climate-related shocks and stresses that the city is vulnerable to, which also contribute to low levels of adaptive capacity. As a result, many of the strategy's goals showed to be closely aligned to broader development goals such as the SDGs (Croese et al. 2020).

Beyond the adoption of relevant policies and the drafting of action plans, the City has focused on mainstreaming climate resilience into various core City strategies, policies, and processes. These include the City's Water Strategy, Cape Town Municipal Spatial Development Framework (SDF) and District SDFs, and disaster risk management plans and procedures. Mainstreaming should be seen as an evolving and iterative process rather than a one-off task as the City's policy landscape is not static.

The diverse implementation challenges include limited budget and resources given the high upfront costs of certain types of interventions, uncertainty regarding the timing and magnitude of various climatic changes, and the need to take a cautionary approach to limit the scope for maladaptation. However, Cape Town's experience of severe drought has meant that the municipality has learned important lessons about proactive planning for extreme events, meaning that uncertainty is less of a constraint than in previous years. This experience has also caused a shift in focus from planning for specific outcomes toward planning that focuses on creating flexible and adaptive systems (City of Cape Town 2020).

One way in which the City aims to address these challenges is through the adoption of an Ecosystem-based Adaptation (EbA) approach which focuses on

green infrastructure, lower cost, and "no-regrets" options as a priority for adaptation. Many of Cape Town's current and future climate vulnerabilities will respond well to an EbA approach aimed at restoring the functioning of various ecosystem services and the ability of natural systems to provide a buffer to climate hazards.

Climate change adaptation and resilience implementation comprise a relatively new work area for the City of Cape Town, although this is rapidly changing as climate impacts are increasingly being felt. However, the adoption of a coastal edge as part of the City's Municipal Spatial Development Framework provides an example of a functioning resilience initiative. The coastal edge is a demarcated area around the coast that has been positioned so as to limit urban development beyond this line. This has been done primarily to protect coastal resources and to avoid hazards and financial risks associated with areas at risk of flooding, storm surges, erosion or accretion, and long-term climate change impacts such as sea-level rise. The coastal edge has been drawn so as to promote nodal development in areas of high economic and social need and to avoid the negative consequences of strip development along the coastline.

3.3 Gothenburg, Sweden

In its 2018 proposal for a national climate adaptation strategy, the Swedish government emphasizes the vulnerability of built environments (Sveriges regering 2018). Amendments (SFS 2018) of the Planning and Building Act (SFS 2010) give municipalities – which, in Sweden, have a monopoly on physical planning – a clear signal regarding the government's perspectives and priorities in terms of climate hazards. Firstly, a requirement has been introduced for municipalities' comprehensive plans to specify (i) what risks they foresee for damage to the built environment due to climate-related *flooding*, *landslides* and *erosion* [emphasis by the authors] as well as (ii) strategies for the reduction or resolution of such risks (Ch. 3, Sect. 5). Secondly, municipal agency is increased through the right to stipulate, in detailed development plans, an obligation for developers to acquire site improvement permits before undertaking measures that may reduce *the permeability of soil to water* [emphasis by the authors] (Ch. 9, Sect. 12) (SFS 2018).

As a city located along the Kattegat in the North Sea and at the mouth of the Göta River and the outlet of other large water systems such as Mölndalsån and Säveån, as well as large areas of the central city located in low-lying backfill areas, the city of Gothenburg is particularly vulnerable to flooding. In addition, the soil is in large part clay, and the city has a topography with hills that lead to rapid runoff toward flat valleys with poor natural infiltration. Consequently, a significant part of the city's resilience work has been on extreme events related to water-related hazards, such as intense rain, sea-level rise, and storm surge. The City has included in its planning the possibility of unexpected and extreme weather events becoming more frequent (Göteborgs Stad 2018a).

The City of Gothenburg is at the forefront of climate change adaptation among Swedish municipalities, and it was early to start analyzing its vulnerabilities and

carrying out technical studies, including the Extreme Weather project and the development of a hydrological model, initiated in 2004 (Glaas et al. 2010).

As of early 2021, the City of Gothenburg is revising its comprehensive plan that dates from 2009. In the draft new version, the City outlines (i) the basic features of the intended use of land and water areas; (ii) the municipality's view of how the built environment should be used, developed, and preserved; and how the municipality intends to (iii) meet national priorities and comply with current environmental quality standards; (iv) take into account and coordinate with relevant national and regional goals, plans, and programs of importance for sustainable development within the municipality; and (v) meet the long-term need for housing.

Gothenburg faces several major societal challenges. The comprehensive plan (ÖP, based on its Swedish acronym) aims to meet, in particular, three of these: (i) segregation, (ii) consumption of natural resources and the impacts of climate change, and (iii) a growing city. The vision of the comprehensive plan is for Gothenburg to be a sustainable city, open to the world. Sustainable urban development is the overall goal of the comprehensive plan, and therefore the focus is to plan and build Gothenburg densely, green and mixed. Resilience, or robustness, as it is often referred to in Swedish, is part of the vision and one of the priority strategies: "Gothenburg of the future is a climate-smart and robust city. It is easy to live sustainably with limited climate impact. Greenery in the dense city is important from both social and ecological perspectives. When the rainfall increases, there are natural areas that can receive water" [translation from Swedish by the authors] (Göteborgs Stad 2020).

As part of the ÖP's strategy for a robust city, a robust society is imagined as able to withstand the unforeseen and meet challenges such as climate change and other risks by planning with flexibility. The City aims to adapt its housing and infrastructure so that they can withstand climate-related challenges such as extreme precipitation, high flows, high sea levels, and extremely long heating periods. The existing comprehensive plan document acknowledges that the biggest challenges ahead for the city are the organization and financing of these measures (Göteborgs Stad 2020). The ÖP includes a number of additional in-depth studies and thematic supplements, including a Flood Risk Plan, approved in 2018. The comprehensive plan is expected to be approved by the City Board (including the Flood Risk Plan as a complement) in 2021. Already in the comprehensive plan of 2009 (Göteborgs Stad 2009), a flood risk analysis was included which considered climate change projections.

The thematic supplement analyzes the flood hazards the city is vulnerable to and proposes planning levels for socially important facilities, buildings, and prioritized evacuation routes. The document outlines goals and strategies for climate adaptation with regard to flood risks in new urban planning, which refers to new exploitation and densification works. The City has mapped which areas are threatened by flooding in the form of high seawater levels, high flows in major watercourses, and torrential rain; these studies form the basis for the recommendations proposed in the thematic supplement. Until recently the city had been planning its construction for a rise of +1 masl, but the flood risk supplement proposes that to be on the safe side, the City should plan using the IPCC's worst-case scenario and thereby be

prepared for the continued sea-level rise which has been projected. Under the IPCC worst-case scenario RCP 8.5 (the Representative Concentration Pathway 8.5 assumes limited mitigation and continued high emissions of carbon dioxide in the long term), the highest water level in 100 years has been estimated at +2.5 masl, with a median of +2.2 masl, including the small land uplift the city has of about 0.3 m (Göteborgs Stad 2018a).

Given the large uncertainties regarding the future climate and seawater levels, the flood risk supplement advocates strategies that build upon continuous adjustments and adapting gradually with the planning strategy divided between the medium- and long-term perspectives. For the medium-term adaptation of the city, the supplement includes planning levels (minimum levels at which is allowed to build different infrastructure) as well as the plans for establishing a high-tide protection along the riverbank to protect low-lying areas. The riverbank protection is expected to be designed so that it can be rebuilt or adjusted if the external barrier becomes insufficient (Göteborgs Stad 2018a). According to current climate change projections, the city's medium-term strategy provides sufficient protection for about 50 years, i.e., to about 2060–2070. At that point, a large-scale technical protection along the river or sea would need to be built.

As part of the City's growth plans while increasing its resilience to extreme rainfall and sea-level rise, the City explored three different strategies: retreat, defend, and attack (Mistra Urban Futures and SWECO 2010). During the retreat strategy, low-lying areas are given temporary simpler land uses (such as piers or parks) so that they can be used when there are no floods and before projected sea-level rise, but recognizing that over time, they may become flooded during most of the year and thus not functional. The defend strategy involves building protective devices, while attack involves building over the water adapting buildings and other structures to the water level, such as with high columns or floating structures (SKL 2017; Mistra Urban Futures and SWECO 2010).

The City is planning to continue developing in low-lying areas along both sides of the Göta River, and taking a combination of the three strategies, with a focus on the defend strategy. One of the largest ongoing urban developments in the City includes building on flooded land in the area of Frihamnen, which borders the Göta River. At the same time, most of the developments will take a defend strategy by raising quays and building ramparts along the river (Göteborgs Stad n.d.). The project also includes measures for the water to escape in the case of a flood, through a combination of blue-green solutions where canals and parks have a multifunctional design as recreational resources that add value and identity to the area during dry periods and can serve as flooded areas and water drainage channels when needed. The ambition is that the Frihamnen area will be the first climate-safe area in Sweden (Göteborgs Stad 2015a).

The city has also constructed rain gardens in public areas such as parking places so that rainwater can quickly drain away from the streets to plant beds. During 2018 the City completed structure plans for flooding in the built-up areas of the catchments where 70% of the inhabitants live. The plans include flood prevention measures such as storage, steering, and draining of cloudbursts through, for

example, raised sides on rivers and streams with openings to allow the flow out of the streets into the streams (Göteborgs Stad 2018b). Current building regulations also require property owners who want to get a building permit for new properties to build a delay drainage, which can be done through rain gardens, before draining to the municipal drainage and sewerage system as a way to reduce the risk of the system being overwhelmed during heavy rainfall events (Göteborgs Stad 2018c).

The City of Gothenburg integrated its environmental and climate programs, and in March 2021 the City Council approved a new Environment and Climate Program valid from 2021 to 2030. It uses as starting point UN's Agenda 2030, Sweden's national environmental goals system, the Paris Agreement, and the challenges facing Gothenburg in coping with the transition to an ecologically sustainable society. The main aim is for the City to become ecologically sustainable by 2030. Under the nature theme, the environmental goal is for Gothenburg to have a high biological diversity. Under climate the goal is for Gothenburg's climate footprint to be close to zero. Within the climate theme and through its goal and subgoals, the focus is solely on reducing greenhouse gas emissions, i.e., on climate mitigation.

Under the people theme, the goal is for Gothenburgers to have a healthy living environment. In this theme the issue of robustness is mentioned as part of the goal description "Gothenburg must be a green and robust city where ecosystem services are used to meet people's needs, now and in the future" (Göteborgs Stad 2021, p. 25). One of the subgoals of the nature theme is for the City of Gothenburg to secure access to green areas and use ecosystem services. Part of the rationale of the program behind this subgoal is that with increased climate change, the green areas in the city will become even more important, both for human well-being and the city's resilience to extreme weather.

While the concept of robustness is included in the program, the document explicitly states that one limitation is the absence of goals for climate adaptation. The focus is instead on reducing the climate impact and thereby reducing future needs for measures for climate adaptation. The program addresses resilience and adaptation by planning for a green and robust city through green infrastructure. Not fully integrating mitigation and resilience runs the risk of missing their potential synergies and conflicts.

Though significant work has been done in building climate resilience and adaptation, the City does not have a comprehensive adaptation strategy. A number of agencies are also in charge of addressing climate change. While the environmental department is in charge of overseeing and coordinating the Environment and Climate Program, the resilience work has mostly been undertaken by the Planning Office, with involvement of the Sustainable Waste and Water Department and the Traffic Office, to name a few (Glaas et al. 2010; Göteborgs Stad 2015b). Since 2017, the City Executive Office (*Stadsledningkontoret* in Swedish) has coordinated the climate adaptation work of the City led by a Climate Adaptation Coordinator (Göteborgs Stad 2018d). Climate adaptation has also been included in the City's regional water supply plan, and resilience is taken into account in the regional waste plan (Göteborgs Stad 2018e, f).

Vulnerability and resilience have been addressed mostly through technical and infrastructure measures, with social aspects that may influence the adaptive capacity of the population not being prominent in the City's resilience work. Also there have been limited dialogues with citizens and awareness-raising campaigns, although information to citizens is increasing (Glaas et al. 2010). Further, the City has not yet explored other potential risks connected to global environmental change, such as invasive species. It also has done limited work on heat waves, an issue which requires further planning and preparedness. During the summer of 2018, Gothenburg reached a heat record of 34.1 °C, the highest temperature recorded since 1868 (SMHI 2018). The drought and heat wave resulted in multiple forest fires, students being sent home from school due to the high temperatures, and a number of people needing medical attention from heat exhaustion, something the city, region, and national governments were not used to handling, even if relevant plans existed (Nilsson 2018).

3.4 Kisumu, Kenya

Like other countries, Kenya has been exposed to a variety of both anthropogenic and natural disasters such as fires, droughts, floods, landslides, HIV/AIDS, human conflicts, drug abuse, traffic accidents, oil spill, industrial accidents, and terrorism (Huho et al. 2016). Over 70% of the disasters are hydrometeorological, namely, droughts, floods, and landslides, with droughts being less frequent than floods. In 2010, Kenya developed a National Climate Change Response Strategy (NCCRS), which identifies agriculture, tourism, infrastructure, health, and natural resources as being the most vulnerable sectors to climate change (Government of Kenya 2010; UNDP 2013).

In addition, Kenya's unprecedented urban growth, which is projected to reach 31.7 million (56%) by 2027, has left Kenyan cities with huge unmet demands for critical infrastructure and basic services, adversely affecting quality of life for urban residents, especially in informal settlements. These relate particularly to clean water, sanitation services, shelter, energy and electricity, transportation and infrastructure, market infrastructure, solid and liquid waste management, and citizen safety and security (Kisumu County Government 2018a).

Kisumu, the third largest city and bordering Lake Victoria, has an estimated population of half a million, around 60% of whom live in informal settlements (Kisumu County Government 2018b). In 2010, only 65% of the water requirements of Kisumu's residents were met, and in 2013, more than three-quarters of the city's water was consumed by those who had piped connections into their houses – less than 10% of the city's population in middle- to higher-income settlements and very few in lower-income areas (WSUP 2018a). Access to adequate sewerage systems is also limited. Most residents living in informal settlements use pit latrines, which are often in poor condition (WSUP 2018b) and overflow during heavy rains. In addition, some of the private pit emptiers dispose of the waste untreated in violation of regulations (such as the Environmental Management and Coordination Waste

Management Regulations from 2006), increasing environmental pollution and health risks for the population.

To address the water and sanitation challenges, the Water and Sanitation for the Urban Poor (WSUP) initiative has worked in Kenya since 2006, forming partnerships with service providers and other stakeholders to create affordable and sustainable water and sanitation services for low-income urban communities (Adams et al. 2016). This involves partnering with Kisumu Water and Sewerage Company (KIWASCO) to strengthen its focus on low-income communities, building its capacity for improved service provision, as well as developing business plans, policies, procedures, and standards. The implementation of a delegated management model has improved water service provision to low-income areas in Kisumu through independent providers within informal settlements (WSUP 2018a). Sustainable management of water and sanitation for all is a key resilience component for Kisumu as it underpins wider efforts to end poverty and advance sustainable development. Making progress on SDG 6 on water and sanitation will enable and drive progress on all the other SDGs, from health to hunger and from gender equality to environmental protection and sustainable growth (UN-Water 2018).

The city is also particularly vulnerable to floods, which displace thousands of people and lead to serious loss of life and property (Masese et al. 2016). The Kibos River traverses Kisumu en route to Lake Victoria and, due to upstream erosion, has formed a lakeside swamp. As a result, the lower Kano plains, which lie at the head of the Kavirondo Gulf and are characterized by alluvial soils with very poor drainage, are prone to flooding during heavy rains (Kisumu County Government 2015). With expected increase in the intensity of rains due to climate change, the poorest population are the most vulnerable to floods. Further, in recent years, harsh climatic conditions have become more frequent, intense, and unpredictable, leading to significant losses to agriculture and livelihoods. The city's reliance on the regional rain-fed agriculture increases exposure and vulnerability to climate variability and change (MoALF 2017). Specific climate change adaptation interventions currently being considered include mapping of climate change vulnerability (biophysical and socioeconomic), development and implementation of a climate change adaptation and mitigation plan, mainstreaming climate change in the sectoral plans, and designing and implementing climate change projects, such as constructing dykes and water plans for flood control (Okayo et al. 2015).

3.5 Malmö, Sweden

In southern Sweden where Malmö is located, the County Administrative Board of Skåne acts locally on behalf of the national government. Its clustering of actions since 2014, as reported in its 2020–2024 action plan for climate adaptation (Birgander and Lundquist 2020), provides indications of the scope of recognized resilience issues of specific relevance to the region. They include sea-level rise, sewage and surface drainage, the supply of potable water, financial liability issues, human health, and land-based industries and the natural environment. The national

government's concerns about climate adaptation are echoed in Malmö, where the City particularly emphasizes its vulnerability to flooding in built environments.

Malmö's coastal location means that it is likely to be affected by sea-level rise as well as by weather-induced storm surge events that push seawater into the city. Such an event occurred in December 2013, with far-reaching economic consequences (Almström 2016). A report from the City Planning Office (Malmö stad 2008) highlighted these risks already in 2008, illustrating various inundation scenarios, and a commissioned follow-up report (Almström 2016) was completed in 2016. In response to threats to future built environments from seawater penetration, the City's latest comprehensive plan (Malmö stad 2018a) includes a requirement not to allow new development on sites that lie lower than 3 meters above current average sea level.

In addition to risks from seawater, high-precipitation events represent an acutely perceived climate-related flooding hazard in Malmö, where cloudbursts have caused widespread damage across the city over the past decades, e.g., in July 2007 and in August 2014 (Almström 2016; Lindher 2015). Recent collaborative research (Larsson 2020) uses vulnerability to cloudburst flooding as a basis for studying overlapping uses of urban spaces. In addition, a 2018 overview report of different urban water management challenges summarizes adaptation needs and vulnerability in Malmö because of flooding caused by both storm surges and cloudbursts (Malmö stad 2018b). Flooding by seawater constitutes a risk primarily to residential and commercial values in the western and northern areas and to those in and near the historic city center. These represent areas of comparative affluence, whereas vulnerability to flooding as a consequence of precipitation is high also in the southern and eastern parts, which are home to a larger share of low-income and socially vulnerable groups. Local hazards are aggravated by poorly planned microtopography in combination with vast areas of impermeable sealed surfaces.

Arguably, to date, the most topical urban climate resilience challenges perceived in Malmö all involve flooding. Heat waves, however, constitute an additional area of vulnerability highlighted in the 2015–2018 environment action plan (Malmö stad 2015a), with mentions of the need for measures in facilities for particularly vulnerable population groups, such as nursing homes, schools, and preschools. Following the exceptionally hot and dry summer of 2018, drafts of the City's forthcoming environment program for 2021–2030 (still to be formally adopted at the time of writing) also add drought to the list of hazards to address in order to increase resilience. Moreover, in the context of nature conservation, sea-level rise may constitute a threat to shallow marine environments and habitats, so-called coastal squeeze (Pontee 2013). Possible resonance to local concern and discussions about this topic in Malmö may be understood in the context of the City's ambitions to be internationally recognized as a high-profile and leading actor in marine environment matters (Malmö stad 2020).

In 2013, the City Executive Board decided to join the UN initiative *Making Cities Resilient* and commissioned the City Office to investigate how to coordinate the City's efforts to reduce risks relating to natural disasters. The following year, a major cloudburst hit Malmö, causing extensive economic damage. The event poignantly

highlighted weaknesses in local preparedness and ability to withstand an occurrence, the probability of which is likely to increase as climate change intensifies. In the aftermath of this event, the City's Streets and Parks Department and VA Syd (the entity responsible for local water, solid waste, and wastewater administration) were at odds with each other and with private property owners over divergent needs, interests, and claims, while realizing that there are, in fact, unclarities as to legal liabilities. Larsson (2020) scrutinizes challenges and disincentives in this context of liabilities, financing, and cooperation. The 2014 event boosted ongoing resilience-focused efforts across various local administrative branches, and in 2017 an official cloudburst plan for the municipality was adopted (Malmö stad 2017). The plan highlights three fields of action: (1) to implement physical changes in particularly vulnerable sites, (2) to consciously include flooding prevention strategies in regular urban development processes, and (3) to actively reach out to property owners in the existing built environment to inform and incentivize them in taking preventive action (Malmberg 2018). To this end, VA Syd has launched a strategic information program entitled "Together, we make space for water" (VA Syd n.d.). The cloudburst plan can be viewed as a specifically climate-related complement of the City's general central crisis management plan from 2015 (Malmö stad 2015b). It is complemented by a plethora of older and current policy documents that address resilience in various ways, such as the annually updated action plan for efforts 2019–2023 to strengthen Malmö as a model for future coastal cities (Malmö stad 2020).

Another concrete example of efforts to increase resilience in Malmö is the progressive action commenced in the 1990s to address flooding due to rains in the neighborhood of Augustenborg, which has become a prominent example of successful flood prevention (Climate-ADAPT 2014; Bernstad Saraiva 2021; Sörensen 2021). Measures include increased capacities for topographic and vegetational water retention, along with increased soil permeability. Nevertheless, for several years the area has remained an exception. Similar measures have still to be disseminated to many neighborhoods with physical conditions akin to Augustenborg's.

3.6 Sheffield, UK

Climate change projections for the Yorkshire and Humber region (where Sheffield is located) predict more frequent and intense heat waves and heavy rainfall in the coming decades (Murphy et al. 2010). The increased risk of winter flooding and summer drought presents major challenges for its cities, including risks to human health, infrastructure, biodiversity, and food security (Hoermann and Nolan 2013). National assessments of flood risk have identified the Yorkshire and Humber region as second only to London in terms of the number of people at risk of flooding (Environment Agency 2009) and the region with the largest proportion of "flood disadvantaged" neighborhoods when underlying socioeconomic and spatial vulnerabilities are taken into account (Lindley et al. 2011). Sheffield's particular vulnerabilities stem from its industrial legacy alongside its location at the foot of the Pennine Hills, its steep topography, five rivers, and more than 240 kilometers of

waterways (Sheffield City Council 2018a; Sheffield Waterways Strategy Group 2014).

Sheffield has most recently flooded in 2007, 2009, and 2012 (DEFRA 2018). In the severe 2007 floods, two people were killed, hundreds of residents were evacuated, and 1,275 homes and over 1,000 businesses were affected (Bhattacharya-Mis and Lamond 2014; Sheffield City Council 2008a), at an estimated total cost to the city of around US$190 million (Hoermann and Nolan 2013). Properties and infrastructure within Sheffield are primarily at risk of fluvial flooding, but groundwater, surface water runoff, and sewer flooding have played a contributory role in previous floods. It is anticipated that climate change will increase both the frequency and severity of flooding (Sheffield City Council 2008b) and that without investment in flood defenses, 6,000 households and 2,000 businesses will be at risk of flooding due to climate change in the next 50 years, at an economic cost of more than US$1bn (Sheffield City Council 2017).

The Council's approach includes dedicated river stewardship of the river channel and banks and natural flood management upstream alongside urban infrastructural development, including flood defenses that are being integrated with new small riverside "pocket parks" (see Fig. 2) (Sheffield City Council 2018a; Sheffield Waterways Strategy Group 2014). The Council is constructing an innovative pilot retrofit Sustainable Urban Drainage scheme – Grey to Green – along 1.5 km of former inner ring road combining surface water storage with attractive water gardens and low-maintenance meadows. This has already attracted numerous design and environmental awards and is believed to be the largest project of its kind in the UK to date. The Council has also begun work to "daylight" parts of the rivers Porter and Sheaf, which includes opening up buried watercourses that were culverted during the industrial era and restoring them to more natural conditions delivering aesthetic,

Fig. 2 Flood defenses integrated with riverside parkland on the River Don in Sheffield. (Photo provided by Sheffield City Council)

natural cooling, flood protection, and stewardship benefits (Cox 2017; Sheffield City Council 2018a).

Sheffield City Council has previously assessed the local impact of extreme weather events, studied citywide vulnerabilities, and published a report on climate change health impacts (Wight 2014). In April 2018 the Council published a Green City Strategy setting out high-level objectives in relation to sustainable urban development, both in terms of climate change mitigation and adaptation. Objective 2 of this strategy focuses on climate resilience, in particular flooding and water management, the effects of heat and drought, and food supply chains. The city's Green Partnership Board was tasked with producing a climate resilience plan by 2020 to "help ensure that our communities, residents, public and private sector are more resilient to climate change impacts, and that they are prepared and able to respond to and recover from extreme weather events should they occur" (Sheffield City Council 2018b, p. 5), but it is not yet complete at the time of writing. While flooding has understandably been a recent priority, this presents an opportunity to develop a holistic, citywide approach to climate resilience.

The main implementation challenge is funding. While the City Council has six major ongoing flood defense schemes at an estimated total cost of £100 million (about US$140 million) – of which around c£40 million (about US$56 million) will be funded by the UK Government through the National Flood Programme (DEFRA 2018; Sheffield City Council 2017) – since 2010 a national austerity program maintained by successive governments has substantially reduced funding for local councils. This has had an impact both in terms of the Council's ability to deliver services on the ground and at a strategic level through the loss of staff expertise through redundancies and departmental reorganization. In this context, English regional and local climate change resilience and adaptation strategies are likely to follow a pluralistic, stakeholder-centered partnership approach (Bauer and Steurer 2014).

3.7 Shimla, India

Shimla, the capital of Himachal Pradesh State in India's Himalayan foothills, lies in an active seismic zone and is vulnerable to several natural hazards. They include but are not limited to earthquakes, landslides, subsidence, flash floods, heavy snowfall, hailstorms, and severe thunderstorms (TARU 2014). Shimla is vulnerable to climate hazards because of its location and topography; different dimensions of vulnerability affect different parts of the city and its inhabitants. As elaborated in the City Disaster Management Plan 2016 (Municipal Corporation Shimla 2016a), infrastructure including roads, water supply, and buildings are vulnerable to hazards. Due to Shimla's geological features, landslides during heavy rainfall are quite common and cause immense loss of life, infrastructure, and economy (Municipal Corporation of Shimla 2016a).

Over the years, Shimla has become a popular tourist destination and has therefore grown considerably, including a large floating population. Population growth in recent decades has increased pressure on resources including land. The expansion

of the built environment in the city as a response to this growth has been largely unplanned and is vulnerable to natural hazards such as earthquakes and landslides (TARU 2014). In addition, the urban infrastructure is old and does not cater to the increased population. Therefore, hazards can affect both local population and tourists. Further, the people as well as the municipal institutions are not well equipped to face hazards. The city's economy, which mostly depends on the tourism industry, is also affected.

Several recent studies and projects have been undertaken to develop resilience strategies and indices. The City Disaster Management Plan 2016 elaborates a response mechanism to ensure preparedness in times of a disaster. It also enlists the responsibilities and action points for the Urban Local Body, the Municipal Corporation of Shimla (MCS), to ensure minimal damage due to climate hazards (Municipal Corporation of Shimla 2016a). The official website of the MCS has a special disaster management section, comprising guides for citizens in cases of emergencies (Municipal Corporation of Shimla n.d.). MCS has also taken certain initiatives to mainstream disaster risk reduction (DRR) into urban planning. In 2015, an action plan to incorporate DRR and climate change adaptation into the sectoral development plan of Shimla was developed through support from USAID and UNDP. It has also initiated capacity building among the citizens and volunteers from medical and defense services. These volunteers have been trained on emergency response and first aid for emergency situations under the "Community-Based Disaster Risk Reduction" project (Municipal Corporation of Shimla 2016b).

ICLEI developed a City Resilience Strategy in 2013, in which it analyzed various urban systems in Shimla. The Strategy identifies vulnerable areas (wards) which are most impacted in times of stress. Water supply, transport, and tourism have been identified as the most vulnerable urban sectors. Tourist centers, where the influx of floating population may be the cause of stressed resources, represent particular vulnerability hotspots. The Strategy also highlights the need to include safeguards to human health, life, and sustainable economy for future resilience-building activities (ICLEI 2017). A more recent City Resilience Index (CRI) developed by Arup International Development for the Rockefeller 100 RC initiative (see Sect. "1" above) examined the shocks and stresses faced by Shimla and incorporated the views of various stakeholders in the city. It also highlighted that data sharing between different levels of government can be improved to better inform a range of activities such as integrated planning and policy development (Arup 2015). In addition, a study reviewing the city's early warning system (EWS) states that the Urban Local Body has to make significant investments in developing the EWS and its associated mechanisms (TARU 2014) since the current level of preparedness is severely inadequate.

At the national level, disaster-specific guidelines issued by national agencies apply to Shimla. The former Ministry of Urban Development (which merged with the Ministry of Housing and Poverty Alleviation forming the current Union Ministry of Housing and Urban Affairs) issued Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines, which integrate guidelines on urban flooding, earthquakes, and landslides among others prescribed by the

National Disaster Management Authority (Town and Country Planning Organisation 2015). These provide guidance to states and cities (including Himachal Pradesh and Shimla) on spatial planning which were also followed up with standard operating procedures (SOP) on management of disasters such as on urban flooding (Ministry of Urban Development 2017). A national-level urban program named Atal Mission for Rejuvenation and Urban Transformation (AMRUT) also mandates incorporating resilience measures against disasters, including floods while preparing city-level Service Level Improvement Plans (SLIPs). Shimla is one of the cities implementing AMRUT.

India has a Disaster Management Act as well as a National Policy on Disaster Management, which mandates the State Government and its departments to integrate disaster risk management into development plans and programs. The State Disaster Management Plan also addresses the mainstreaming of disaster risk reduction (DRR) in order to ensure that development does not exacerbate risks of disasters and that it is protected from the existing and future risks as well. Several other current national- and state-level projects in Shimla have the potential to integrate DRR aspects into their activities. For example, hazard-resistant housing can be integrated into the national-level *Pradhan Mantri Awas Yojana* scheme (an initiative to provide affordable housing to urban poor). Under the Smart Cities Mission and AMRUT, training and capacity-building programs for municipal officials on DRR, inclusion of strategies for disaster management in city development plans can also be explored (Himachal Pradesh State Disaster Management Authority 2017).

All the aforementioned studies and strategies, including the City Disaster Management Plan, highlight the importance of improving interdepartmental coordination. Since most urban systems are maintained by agencies at various levels – city as well as state level – better coordination between them will minimize disruption of services due to climate hazards. A decentralized effort of implementing DRR strategies at local level with active involvement and awareness of citizens may also make disaster and climate resilience planning more effective and help build urban resilience.

4 Discussion and Conclusions

This chapter has examined the particular complexion and diversity of urban resilience challenges across a range of urban areas worldwide. The conceptual introduction explained the unprecedented way in which the crucial role of urban and other subnational authorities has been recognized and incorporated into major recent global disaster risk reduction, sustainability, climate change, and resilience agendas approved and agreed upon between 2015 and 2016. Detailed case studies from a comparative research project of seven cities on four continents have then illustrated the resilience challenges each city is facing and preparing to face under a changing climate, as well as the policies and initiatives municipalities have developed to address them. The international global agendas have served in part, together with

national policy frameworks, as basis for prioritizing, backing, and providing impetus to local climate resilience work.

The considerable diversity that has emerged precludes simple categorization and demonstrates the inappropriateness of familiar dichotomies such as between Global North and South, between economic core and more peripheral countries within a particular region, or between coastal and landlocked cities or a metropolitan region and small-intermediate-sized cities. For instance, flooding is common to most of these cities, regardless of their position in relation to these dichotomies. Whether this particular hazard originates in the sea, a river, or changing rainfall patterns (or a combination of these) is probably less significant per se than how current and anticipated future flooding intersects with the physical, social, and economic geographies within each city and their associated coping capacities, vulnerabilities, and potential resiliences. Far more useful, therefore, is to understand the full spectrum of risks and vulnerabilities across all sectors or categories and how these are experienced, perceived, and addressed individually and in combination in cities. This is what makes each city unique in one sense but also provides a more systematic basis for understanding the challenges and identifying where knowledge and experience could most usefully be shared. Hence, for example, how Sheffield and Shimla are responding and need to address flood risk is quite different – despite both being inland cities with changing rainfall patterns as a contributory factor – because of how this hazard intersects with their many other relevant differences such as topography, tectonic risk, climate variability, economic and social structures, wealth distribution, and poverty profiles.

Furthermore, most of the case study cities have, thus far, focused on technocratic-style solutions or are still at the stage of hazard analyses and solutions aimed at reducing the impacts of the hazards. However, another important aspect that has not yet been given enough attention is the varied impacts of those hazards across socioeconomically diverse populations. This technocratic and usually top-down approach is not unique to the seven study cities. An analysis of 885 cities in Europe (Reckien et al. 2018) as well as the IPCC special report on extreme events (SREX) found similar trends (IPCC 2012, p. 312). The top-down approaches also reflect varying extents to which local authorities, particularly smaller municipalities, depend on regional and national policy framings for local implementation. Even in highly decentralized countries where participatory planning and citizen engagement are promoted, such as Sweden, municipalities have adopted top-down technocratic approaches with only limited citizen involvement, reflecting discrepancies between rhetoric and practice. Further, while some of the case study cities have depended more on regional- or national-level guidance, such as Kisumu and Shimla, in others, climate resilience planning and implementation have been initiated at the city level through their planning or executive departments, as in the case of Cape Town, Buenos Aires, and Gothenburg. Increasing the resilience of urban populations to hydrometeorological and geophysical hazards also requires increasing their adaptive capacity by improving socioeconomic conditions, reducing inequalities, as well as substantive participatory planning and capacity-building and awareness programs that actively engage citizens.

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