Introduction

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Pathways to Urban Transformation

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Pathways to Urban Transformation

The Five Pathways

Five pathways to urban transformation emerge throughout the *Second Urban Climate Change Research Network Assessment Report on Climate Change and Cities (ARC3.2)*. These pathways provide a foundational framework for the successful development and implementation of climate action in cities. Cities that are making progress in transformative climate change actions are following many or all of these pathways. The pathways can guide the way for hundreds of cities – large and small, low-, middle-, and high-income – throughout the world to play a significant role in climate change action. Cities that do not follow these pathways may have greater difficulty realizing their potential as centers for climate change solutions. The UCCRN ARC3.2 Pathways are:

- *Pathway 1 – Integrate Mitigation and Adaptation*: Actions that reduce greenhouse gas (GHG) emissions while increasing resilience are a win-win.
- *Pathway 2 – Coordinate Disaster Risk Reduction and Climate Change Adaptation*: Disaster risk reduction (DRR) and climate change adaptation (CCA) are the cornerstones of resilient cities.
- *Pathway 3 – Co-generate Risk Information*: Risk assessments and climate action plans co-generated with a full range of stakeholders and scientists are most effective.
- *Pathway 4 – Focus on Disadvantaged Populations*: Needs of disadvantaged and vulnerable citizens should be addressed in climate change planning and action.
- *Pathway 5 – Advance Governance, Finance, and Knowledge Networks*: Developing robust city institutions, advancing city creditworthiness, and participating in city research and action networks enable climate action.

1.1 Introduction

At the United Nations Framework Convention on Climate Change Conference of the Parties (COP21) held in Paris in December 2015, cities[1] were recognized as key actors in both mitigation and adaptation, which are now understood as encompassing low emissions development and resilience. The COP21 Paris Agreement, entered into force in November 2016, highlights the significant role that cities play in implementing national commitments: *"Agreeing to uphold and promote regional and international cooperation in order to mobilize stronger and more ambitious climate action by all Parties and non-Party stakeholders, including … cities …"* As is now widely acknowledged, cities can be the main implementers of climate resiliency, adaptation, and mitigation. The Second Urban Climate Change Research Network (UCCRN) Assessment Report on Climate Change and Cities (ARC3.2) addresses the critical question of under what circumstances this advantage can be realized. Cities will not be able to address the challenges and fulfill their climate change leadership potential without transformation.

ARC3.2 aims to provide the knowledge needed for cities to achieve transformation in order to fulfill their emerging role as prime actors in low emissions development and resilience. ARC3.2 synthesizes a large body of studies and city experiences and finds that transformation is essential if cities are to excel in their role as climate change leaders. As cities mitigate the causes of climate change and adapt to new climate conditions, profound changes will be required in urban energy, transportation, water resources, land use, ecosystems, growth patterns, consumption, and lifestyles. New systems for urban sustainability will need to emerge that encompass more cooperative and integrated urban-rural, peri-urban, and metropolitan regional linkages.

Cities are a prime source of greenhouse gas (GHG) emissions and thus collectively represent a significant opportunity to promote climate mitigation. In regard to resilience, climate change in cities encompasses a wide range of direct and indirect impacts, with more frequent extreme temperatures, exacerbated coastal and inland flooding, increases in vector-borne diseases, and heightened water shortages posing risks to infrastructure, resource availability, health, and ecosystems.

Although there is great potential for cities to respond to climate change with transformative solutions of global significance, early actions to date in cities have mostly been incremental. However, international urban climate change networks are gaining strength, city climate change programs are being funded by national governments and foundations, and individual cities are taking on responsibility for both reducing GHG emissions and building resilience. This leadership role of cities is likely to expand and deepen as the implementation phase of global climate action, initiated in Paris in 2015 and entered into force as international law in November 2016, gets under way.

Climate change impacts have widely varying consequences on cities as diverse as New York, Mexico City, Lagos, Shanghai, and Indore. As cities develop their own individual responses to increasing climate risks, a strong knowledge base of cutting-edge science and case studies of effective actions in other cities can contribute to effective and efficient decision-making. Furthermore, urban planning and decision-making at the city level needs to be complemented by policy-making and actions at state, regional, and national levels as well.

For ARC3.2, the Urban Climate Change Research Network (UCCRN) has engaged with urban decision-makers and communities of practice[2] to synthesize the necessary pathways to transformation – both the mechanisms by which urban areas respond to risks and the links between urban mitigation and adaptation. Only through transformation can cities rise to the dual challenge of protecting their vulnerable populations and economic activities from increasing climate risks while taking actions to reduce GHG emissions, the root cause of climate change.

1.2 Urbanization, Transformation, and Sustainable Development

We now live on an urban-dominated planet (see Box 1.1). More than half of the world's 7.3 billion people live in cities, and almost all of the projected population growth at least through the year 2050 is expected to take place as part of the urbanization process (UN Population Fund [UNPF], 2015). According to the UNPF, it is likely that two-thirds of the world's population will live in cities by 2050 and that urbanization will be especially dramatic throughout Asia and Africa and in smaller urban areas (Seto et al., 2011). Not only does the majority of the world's population live in cities, but also the large majority of the world's wealth-generating capacity (likely 90% or more) takes place in cities (Seto et al., 2012). As a result, the prospects for global sustainability will be determined primarily by what happens in cities. As centerpoints for human settlement and economic activity, cities have become the focus of attention with respect to GHG emissions and climate risk exposure and vulnerability, and thus leading actors in climate adaptation and mitigation.

Urbanization can be defined as a set of system-level processes through which population and human activities are concentrated at sufficient densities at which a variety of scalar factors become present that in turn can promote further agglomeration effects. The most obvious manifestation of the urbanization process is the conversion of non-urban land to urban land uses. Urbanization not

1 Cities are defined here in the broad sense to be urban areas, including metropolitan, suburban, and peri-urban regions.
2 City decision-makers and communities of practice encompass a broad range of stakeholders that includes municipal governments, civil society groups, local organizations, international agencies, and donors.

Box 1.1 Demographics and Climate Change

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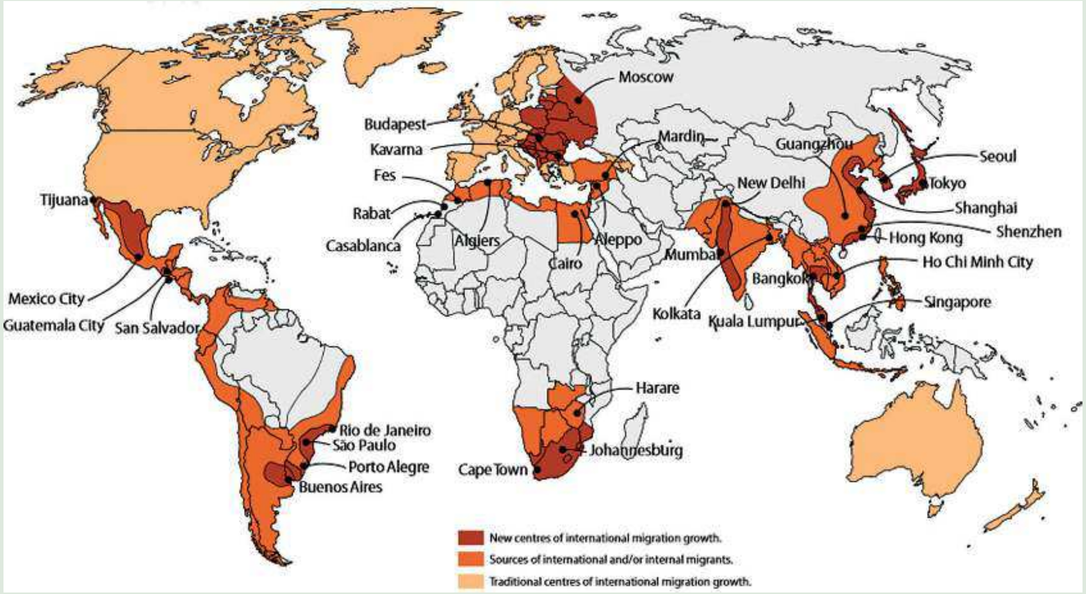
A few years ago, the world population turned for the first time from majority rural to majority urban. With high proportions of city-dwellers in the Americas, Europe, and industrial countries of Asia and Oceania, this trend is seen as irreversible. Countries vary widely in the proportion of the population living in cities. Most Asian countries are predominately rural today, even while being home to some of the world's largest urban areas (UN Dept. of Economic and Social Affairs, Population Division, 2014, 2015).

These trends have important implications for climate change. Low-lying coastal zones are more likely to be disproportionately urban (McGranahan et al., 2007) thus implying that urban residents, more so than rural ones, will experience the untoward effects of hazards associated with seaward climate-related change (e.g., increased frequency or severity of coastal flooding). Cities dwellers are different from the general population in other ways as well. Cities tend to have somewhat younger age structures than the rest of the population, in part because cities receive migrants from other cities, towns, and rural areas and because migrants themselves tend to be young (Montgomery et al., 2012).

The relationship between migration and climate change, including internal migration to cities, is commonly understood as flight from climate impacts or, in extreme instances, migration driven by existential threats, as in the case of some small-island developing states. Yet the history of natural disasters shows that most displacement is relatively short term and local (Tacoli, 2009). Environmental drivers have always been a component of mobility, but the full calculus of migration includes social and economic factors as well. Given rural to urban migration, often toward coastal cities, significant amounts of internal migration may be increasing people's geographic exposure to climate hazards while at the same time improving and diversifying livelihoods. The net effect of urbanization driven by rural-urban migration on climate resilience is therefore highly contingent on circumstances, climate threats, and the protection factors in place.

City size is an often overlooked characteristic of development, with much attention being paid to mega-cities. In the developing world, only 12% of urban population lives in cities of 10 million persons or more, whereas about one-quarter of urbanites live in relatively small cities with populations of 100,000–500,000. Small cities tend to grow faster than large cities (Balk et al., 2009). Yet, small cities with far fewer resources may find this faster growth particularly challenging. Decentralization and the pressures of local governance further complicate or hamper the task of climate adaptation, where many interventions will be local. Even in terms of mitigation, secondary and tertiary cities may be at the mercy of



Box 1.1 Figure 1 *Global diversification of migration destinations.*

Source: IOM, 2015. Adapted from Skeldon, 2013 regulations designed for the biggest cities. City growth itself bears consideration: it may impact urban water availability well before the full effects of a warmer climate are realized in the second half of the 21st century (McDonald et al., 2011) (see Chapter 14, Urban Water Systems).

In terms of mitigation, the relationship between the demographic phenomenon of urbanization – or the increasing share of population that lives in urban areas – and GHG emissions is complex and is greatly dependent on a number of other factors. Urban areas are disproportionately the sources of emissions globally, and, in that sense, the trajectory of urbanization is correlated with the trajectory of emissions growth (O'Neill et al., 2010). However, much of this effect is driven by the concentration of wealth in cities; controlling for income, urban living is more energy efficient than rural living, meaning that the broad-scale shift of population from rural to urban provides the potential for a significant mitigation benefit (Dodman, 2009a). Yet the link between urbanization and emissions also depends on income and wealth, including their distribution in society, as well as on technologies for energy use and urban form (Dodman, 2009b). Cities are also home to smaller households with more independent dwelling units overall; this is complicated because an increasing share of these households are elderly, which tends to lower emissions (O'Neill et al., 2010; Zagheni, 2011). Scenarios of population, economic factors, and technology – for instance the shared socioeconomic pathways (SSPs) (Hunter and O'Neill, 2014) – are useful in global and regional studies assessed by the Intergovernmental Panel on Climate Change (IPCC). Understanding trajectories of emissions and population change in cities is critical for identifying the best approaches to mitigation and adaptation.

For further coverage of this topic, see Box 6.4 in Chapter 6, Equity and Environmental Justice.

only transforms specific sites where cities are located and growing, it is a condition that also has created a web of global-scale resource supply, demand, and waste distribution chains resulting in impacts far beyond city borders. The metabolism of cities has impacts throughout the globe and is responsible for the transport into cities from nearby hinterlands and far-distant locations of primary resources such as energy and water, secondary resources including timber and building materials, and agricultural products.

Cities and their residents have the potential to play an important role in responding to climate change, but concerted transformative action is necessary to overcome the negative effects of the urbanization process. Given the clustering of economic activities, cities often become sites of increased per capita resource consumption in comparison to rural areas. Urban dwellers, particularly in low-income countries, may have relatively higher incomes than their rural counterparts so they tend to consume more. At the same time, density provides economies of scale and resource-use efficiencies so that more people are served with fewer inputs, albeit at higher aggregate consumption (Wenban-Smith, 2009). A case in point is GHG emissions: cities produce approximately 70% of CO_2 emissions (depending on measurement protocols) yet the per capita energy consumption of urban residents tends to be lower than that of rural residents in developed countries (UN-Habitat, 2011; Seto et al., 2014).

In regard to resilience, urbanization concentrates population, infrastructure, and economic activity thus potentially exacerbating vulnerability to extreme climate events. In addition, cities are defined by complex interdependent infrastructure systems and established social and financial networks. Understanding and integrating these circumstances into ongoing climate efforts presents a clear opportunity for enhanced resilience.

In ARC3.2, larger-scale mitigation and adaptation actions are presented within the context of transformation (see Box 1.2). Transformations are defined as the conditions under which system-level changes take place when the integrated urban energy and risk-management regimes of a specific site, sector, or institution are fundamentally altered as one management regime is replaced by another regime. Transformation opportunities and contexts are explored explicitly in several chapters of ARC3.2 (see Chapter 3, Disasters and Risk; Chapter 4, Mitigation and Adaptation; Chapter 5, Urban Planning and Design; and Chapter 16, Governance and Policy).

1.2.1 Cities as Urban Social-Ecological Systems

In this volume, we understand cities to be complex social-ecological systems (SES), uniquely endowed with attributes and functions that enable them to be the first and leading responders to climate change challenges in both mitigation and adaptation (Redman et al., 2004). Urban system are dynamically interactive at multiple spatial or temporal scales (see Figure 1.1). They consist of social and ecological components (broadly defined) that have their own internal processes; at the same time, these processes interact across the entire urban system in a variety of ways to produce overall urban system forms and dynamics. Drivers external to the urban system are fundamentally important and affect the social and ecological components and processes with different strengths or intensity. This conceptual approach to studying urban SES is scale-independent and can therefore be applied at multiple spatial or temporal scales (see Chapter 8, Urban Ecosystems).

The role of technology in the structure, metabolism, and management of cities is profound. The operation and potential failure of the technological systems of cities have important implications for the resilience of urban areas. Climate extremes in urban contexts reveal the potential for catastrophic collapse resulting from large-scale disturbances and cascading system failures. At the same time, the integration of social, ecological,

Box 1.2 Urban Climate Change Transformation

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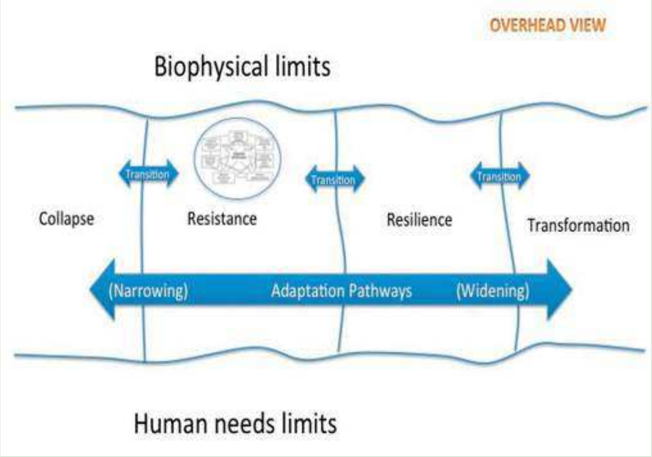
Transformation in the context of systems is found when a system, subsystem, or system components are no longer tenable and are replaced with a new system-level configuration. Expressed differently, this implies that the limits of resilience, adaptive capacity, and hence sustainability of the *status quo* are exceeded and incremental reforms are inadequate, with the result that systemic changes become inevitable and essential. Likewise, urban energy systems will undergo similar systemic change as forms of high-carbon development become untenable. The integration of larger-scale mitigation and adaptation actions are presented in the ARC3.2 within the context of transformation.

Transformations are defined as the conditions under which system-level changes (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems) take place when the urban energy and risk-management regimes of a specific site, sector, or institution are fundamentally altered as one management regime is replaced by another new regime that integrates both mitigation and adaptation. Transformation opportunities and contexts are explored explicitly throughout this ARC3.2 volume.

Transformation opens new policy options once resilience and energy systems meet their limits. Transformation targets the root drivers of unmet sustainable development needs where these constrain mitigation, adaptive capacity, and action (see examples in Marshall et al., 2012). Intentional transformation of one system or object may allow the maintenance of systems at other scales (e.g., relocation of households exposed to risk will be transformative for the households involved, for the places of origin, and for the destinations) and may require legislative change. At the same time, relocation may help maintain wider political and economic or social stability. Forced transformations may open greater scope for uncertainty in the behavior of surrounding systems. In comparison, transformation has been developed from a broad range of social science frames particularly focused on development theory and political ecology approaches (Welsh, 2014; Brown et al., 2013; Brown, 2014; Cote and Nightingale, 2011).

Transformations involve large, abrupt, and persistent changes in the structure and function of a physical or social system, such as changes in governance structures or policy objectives. They can open up the possibility of new rights being extended, of greater social and economic equality and greater political participation, and of sustainable development in response to a stressor or shock. Transformations provide abrupt redirecting to alternative development pathways for the system of interest. It may be that the system undergoing transformation is localized and discrete in sector terms, or it may be grand and all-encompassing. Thus, these shifts can be small and local or very widespread in their effects. A transformative state also can be one that is highly dynamic and potentially difficult to predict (Simon and Hayley, 2015; Solecki et al., 2016). As formulated in ARC3.2, urban climate change transformation integrates mitigation and resilience and leads to fundamental regime shift at both local and larger systems levels.



Box 1.2 Figure 1 *Adaptation activity sphere, transitions, and pathway. Time in this diagram is not left to right. Adaptation pathways can move from a lower state to a higher state (i.e., from left to right) or from a higher state to a lower state (i.e., right to left). Time is referenced from the current to moments or eras in a future time.*

Source: Solecki et al., 2017

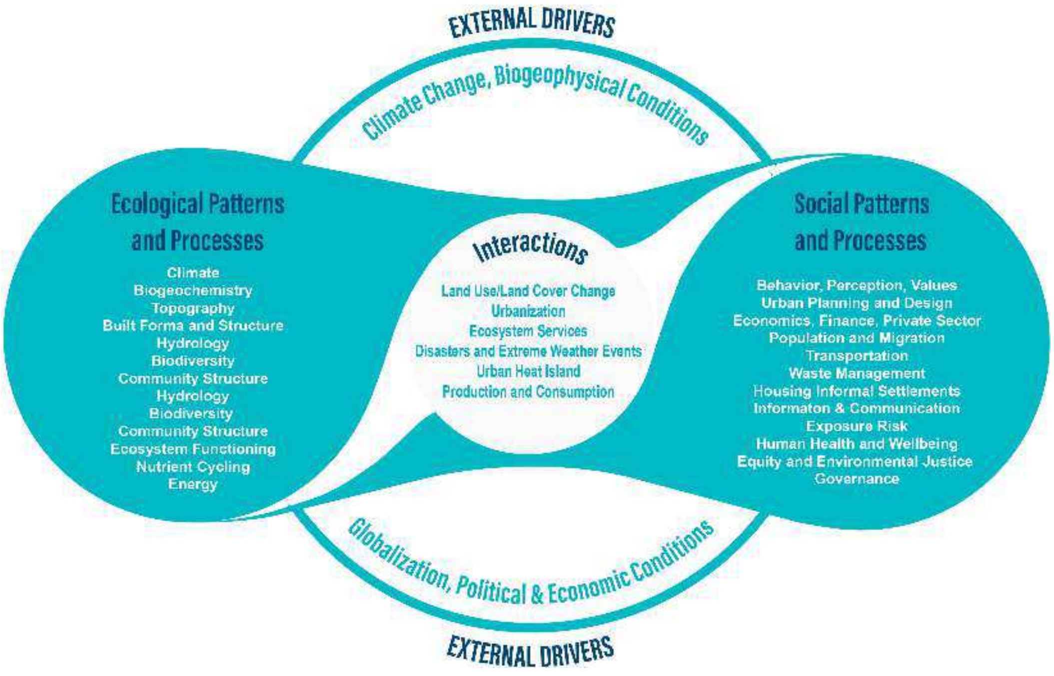


Figure 1.1 *The urban social-ecological system.*

Source: Adapted from Redman et al., 2004

and technological systems in cities provides transformative avenues leading to urban climate adaptation and mitigation.

The use of an urban systems approach is valuable for assessing climate risks and impacts, as well as adaptation and mitigation opportunities and challenges. Systems can operate in a variety of ways including simple linear and complex non-linear interactions and responses. Urban system sectors typically involve relatively well understood, linearly structured engineering systems but are embedded in complex societal and ecological systems with non-linear structures. The systems approach provides a framework for understanding the role and significance of stresses on the operation of urban sectors, metrics of resilience, and early-warning signals of potential system crises and pending system tipping points.

Finally, planning and governance are key dimensions of cities as SES (see Chapter 5, Urban Planning and Design, and Chapter 16, Governance and Policy). Urban climate change governance is the set of formal and informal rules, rule-making systems, and actor networks at all levels (from local to global), both in and outside of government, that are established to steer cities toward mitigating and adapting to climate change (Biermann et al., 2009). Urban climate change governance occurs within the broad context of the SES, with actors and institutions at a multitude of scales shaping the effectiveness of interventions.

1.2.2 Disaster Risk Reduction and Climate Resilience

In laying out concepts related to disaster risk reduction (DRR), ARC3.2 moves from the earlier linear impacts-centric framing of climate hazards, vulnerability, adaptive capacity, resilience, and impacts to an ongoing process-based decision-centric framing that explicitly includes the roles of stakeholders and institutions, governance, capacity building, and exposure reduction (see Figure 1.2) (see Chapter 3, Disasters and Risk). This framing explicitly incorporates elements of DRR and climate change adaptation and highlights operational, management, and governance opportunities for defining connections between the two. Resiliency presents an effective vehicle for highlighting these linkages because it can be applied to both the post-disaster context as well as to the longer-term transformations associated with climate change adaptation.

Often, city governments are the first level of connection to address resilience and DRR in urban areas; however, they often lack technical, knowledge-based, and financial capacities. Regional and national governments need to be engaged through legislation that expands city mandates on DRR and climate change.

Currently, many initiatives are assisting city governments in addressing their needs for building urban resilience and reducing disaster risks. The newly implemented "Ten Essentials"[3] of the *Making Cities Resilient Campaign* of the United Nations Office

3 http://www.unisdr.org/files/26462_13.tenessentialschecklist.pdf

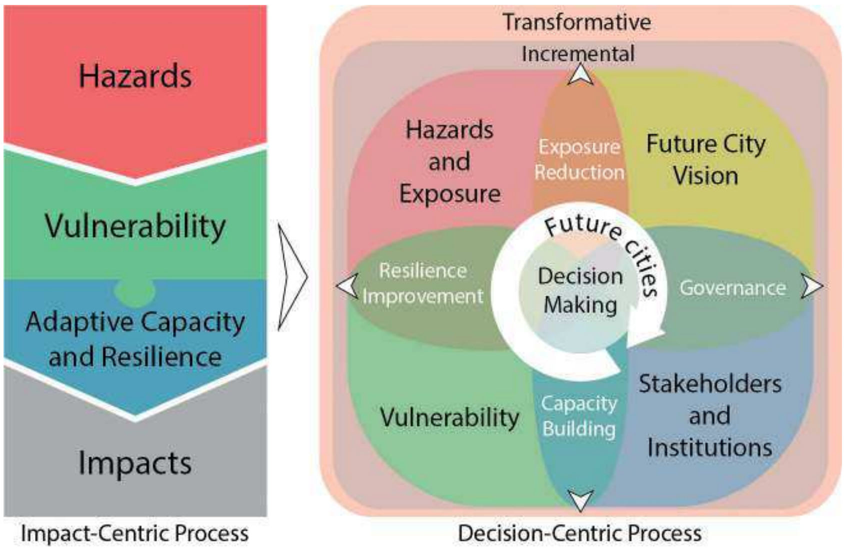


Figure 1.2 *Shift from impact-centric to decision-centric process for disaster risk reduction and climate resilience.*

Source: Xiaoming Wang and Ebru Gencer, 2014; adapted from Xiaoming Wang, 2014

for Disaster Risk Reduction (UNISDR) have provided city governments with practical tools and indicators to build their resilience (see Box 3.3). Currently, nearly 3,000 cities worldwide have joined the Making Cities Resilient Campaign and will be able to use these tools to advance their activities toward DRR and resilience building.

The United Nations Human Settlements Programme (UN-Habitat) City Resilience Profiling Programme (CRPP) is another initiative exploring and providing tools to measure resilience to multihazard impacts and is currently testing these tools in ten pilot cities (UN-Habitat, 2016). The Rockefeller Foundation's 100 Resilient Cities initiative is another program that focuses on building resilience through direct collaboration with city governments (Rockefeller Foundation, 2016) (see CAG 1.6).

1.2.3 Cities, Sustainability, and the Low-Carbon Urban Transition

Urban climate change transformation as presented in ARC3.2 requires the comprehensive integration of mitigation and adaptation. It brings profound changes in energy and land-use regimes, growth patterns, production and consumption, lifestyles, and worldviews (Denton et al., 2014). Some of these actions target the underlying drivers of GHG emissions and vulnerability, such as systems of production and consumption, and the social inequalities that give rise to the coexistence of sub-standard housing, illiteracy, and poverty alongside wealth-related consumptive patterns. As such, transformative climate change actions hold the potential to trigger a broader shift toward sustainable and resilient development pathways (Shaw et al., 2014; Burch et al., 2014).

Just as climate change responses in cities cannot proceed without understanding the larger context of sustainability, sustainability goals cannot be met without explicit recognition of climate change and the role of cities. The year 2015 not only culminated in the Paris Agreement at the 21st Conference of the Parties for the United Nations Framework Convention on Climate Change (UNFCCC); it was also the year that the nations of the world adopted the Sustainable Development Goals (SDGs) (Sustainable Development Solutions Network [SDSN], 2013) (see Box 1.3). A worldwide campaign was successful in achieving a stand-alone urban sustainability goal, SDG11, to "Make cities and human settlements inclusive, safe, resilient and sustainable." SDG11 targets include:

> *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 (SDSN TG09, 2013).*

Climate change and sustainability were thus explicitly intertwined in the major policy actions of 2015.

A critical aspect of the movement to sustainability and transformation is the transition to low-carbon cities (see Chapter 12, Urban Energy). The connection between urbanization and GHG emissions is complex (Bulkeley et al., 2012; Bulkeley et al., 2014; Sachs and Tubiana, 2014). Cities present opportunities for resource-use efficiency across a large population. At the same time, rural to urban migration is associated with increased energy demand because citizens in cities are often wealthier and better able to access energy-intensive technologies. Researchers and practitioners are actively attempting to define mechanisms to promote technologies and governance structures that enhance opportunities to promote lower energy demand and uses in cities, a multifaceted social-technological transition.