OECD Regional Development Working Papers 2018/02

Indicators for Resilient Cities

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https://dx.doi.org/10.1787/6f1f6065-en

OECD

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By Lorena Figueiredo, Taku Honiden and Abel Schumann

This paper discusses approaches to strengthen and monitor urban resilience through the use of indicators. Resilience is the capacity of a city or community to prepare for, respond to and adapt from dangerous and disruptive events, such as natural disasters, economic crises, demographic changes, health epidemics and others. Given that resilience is a multi-dimensional phenomenon, local authorities should design and implement strategies for urban resilience that integrate economic, social, environmental and institutional aspects. In order to monitor progress in becoming more resilient, local authorities should use indicators that measure resilience along these dimensions. The paper analyses different types of indicators and discusses the contexts in which they should be used. It provides recommendations on how local authorities can choose indicators tailored to their policy priorities and develops guidelines for the effective use of indicators in a broader governance framework.

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Authorised for publication by Lamia Kamal-Chaoui, Director, Centre for Entrepreneurship, SMEs, Regions and Cities, OECD.

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Introduction

Cities are complex systems, weaving together thousands of economic, social, institutional and environmental threads that powerfully affect individual and societal well-being. Across OECD countries, metropolitan areas[1] cover only 4% of the land, but account for roughly half of the population and close to 55% of gross domestic product (OECD, 2015a). The world's urban population is now expected to grow from 3.9 billion today to roughly 6.3 billion in 2050 (UN DESA, 2014).

As urban areas and the urban population continue to grow, so will the scale and impact of shocks and stresses upon them. These stresses include but are not limited to industrial structural changes (e.g. relocation or closure of a city's key firms), economic crises (for example, the global financial crisis of 2007/08 and the European debt crisis of 2009), population inflows/outflows; disasters (i.e. earthquakes, floods and hurricanes), disruption of energy supplies, and leadership changes. Large cities are particularly vulnerable to risks, once any sort of shocks to such complex systems will have significant economic, social, environmental and institutional repercussions.

To illustrate, Hurricane Katrina, which hit the city of New Orleans in 2005, claimed more than 1 800 lives and caused USD 125 billion in economic damages (OECD, 2014b). The Great East Japan Earthquake of 2011 caused widespread damage and initiated tsunami waves that devastated coastal areas, what led to a major nuclear accident in Fukushima. Damages were estimated in USD 210 billion and more than 17 000 people were reported dead or missing (OECD, 2014b). The downsizing of Nokia negatively affected employment levels in the city of Tampere, which lay in 18.9% in 2016, more than twice the Finnish national average of 8.8% (City of Tampere, 2016).

If cities concentrate risks, they also concentrate resources and opportunities to become more resilient. Urbanisation brings economic, social and environmental benefits to individuals and countries (OECD, 2015a). Cities concentrate resources – capital, infrastructure, social networks, skills and innovation – that can be invested in preventing, adapting and recovering from shocks and stresses. Local stakeholders are the ones most apt to understand to which risks their city is subject and to act upon them. In this sense, the city is both a territory from which risks can be assessed and a level of government in which action can and ought to be taken.

The central question of this paper is: how can local governments promote resilient cities? This question unfolds into several elements, summarised in Table 1. Local policy-makers should understand what resilience is, why it is a legitimate policy goal and how they can develop a local resilience strategy (Chapter 1). They can then move to the question of how to measure the current state of their city and monitor the effectiveness of resilience policies – the issue of indicators (Chapter 2).

[1] Metropolitan areas are defined by the OECD as functional urban areas of 500 000 residents or more.

Table 1. Fundamental questions

Chapter 1: Towards resilient cities	Resilience to what?	What are shocks, stresses, risks, hazards or disasters? Are disasters perceived differently by different stakeholders?
	Resilience at what scale?	How resilience should be addressed at the different scales (global, national, regional, local and household? How do these different scales interact?
	Why resilience?	What is resilience? Why are cities an arena for action? What are the qualities of resilient cities? What are the dimensions of resilience?
Chapter 2: Governing and measuring urban resilience	How to govern risks and build resilience?	What is risk governance? How can indicators contribute to more effective policy processes?
	How to measure the resilience of cities?	What are indicators and how are they useful? What do they measure: inputs, outputs, outcomes or processes? Can one measure urban resilience or does one have to resort to proxies? How do indicators relate to policy objectives?
	How to compose local sets of indicators?	How to design and use indicators adapted to the local context? What are the indicators that most cities should be concerned with?

Source: Meerow, S., J.P. Newell and M. Stults (2016), "Defining urban resilience: A review", https://doi.org/10.1016/j.landurbplan.2015.11.011 and own elaboration.

The paper gives theoretical guidance and practical advice to local policy makers on how to develop their local resilience strategy. Cities need to start with a risk assessment identifying shocks and stresses that the territory is or may be facing in the future. They must gather the relevant local stakeholders, in order to understand the local context and to build alliances that will later on facilitate implementation. By designing a resilience plan, cities can integrate risk management into different policy sectors, such as transportation infrastructure, land-use planning, education and employment. Cities can then implement resilience policies, under a clear and strategic long-term vision. Implementation has to be regularly evaluated, what can be done through policy indicators. Policy indicators can measure resilience levels and track progress of resilience policies.

Even though this path may look common to many cities, the content of the resilience plan and policies will vary. Each city has their own policy objectives and priorities, depending on their context and most pressing risks. In this sense, cities should develop context-specific resilience strategies. Different cities may adopt different policy approaches to reach their goal of greater resilience. If facing industrial changes that led to high unemployment, they may prioritise innovation policies. When confronted with fast population growth, they may direct more efforts to improve the urban infrastructure of water and energy. The focus of policies varies with the challenges faced.

The different strategies should nonetheless share the overarching goal of more sustainable and inclusive cities. The key global agreements, among them the New Urban Agenda, the Agenda 2030 for Sustainable Development and the Paris Agreement on Climate Change, have set the promotion of resilient cities as one of the main pathways towards sustainable and inclusive urban development (see Annex 1).

1. Towards Resilient Cities

1.1. Cities at risk

Risk, hazard, vulnerability and disaster are terms of the resilience literature that relate to one another. For instance, risk can be defined as a function of hazard and vulnerability. The probability of a dangerous event taking place (the hazard) only becomes a risk if it can negatively affect individuals, communities or systems, i.e. if these actors are susceptible to the impacts of hazards (vulnerability). Disaster risk, for its part, relates to the potential negative effects of a hazard, determined as a function of exposure to risk and the capacity to act upon it (Table 2).

Table 2. Basic concepts around risk and resilience

Risk	Risk is the likelihood of a hazardous event happening, expressed as a function of the vulnerability of a population group.
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hazards may be natural, anthropogenic or socio-natural in origin.
Disaster	A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.
Disaster risk	The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.
Shocks	Sudden events that affect the performance of a system, such as disease outbreaks, floods, high winds, landslides, droughts, earthquakes, outbreaks of fighting or violence, or severe economic volatility.
Stresses	Longer term trends that undermine the performance of a given system and increase the vulnerability of actors within it, such as natural resource degradation, loss of agricultural production, demographic changes, climate change, political instability, economic decline. Stresses can be cumulative, compounding gradually until a tipping point is reached, and transformed into a shock.
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Source: United Nations, General Assembly (2017a), and own elaboration.

Hazards, disasters, shocks and stresses, despite slightly different definitions (Table 2), share important elements in common. They refer to **dangerous and disruptive event**s that have negative impacts on systems. They may be of natural, technological or social origin. Examples are earthquakes, floods and hurricanes, but also outbreaks of violence, migration crises, water contamination, nuclear incidents, economic recessions and health epidemics. Hazards, shocks and disasters are often unpredictable events, while stresses, for being long-term trends, tend to be foreseeable and predictable. In sum, predictable or not, these events are dangerous and disruptive.

Albeit always disruptive, some shocks may eventually bring positive outcomes. They can provide an opportunity to reconsider the economic, social, environmental and

institutional structure of a city. For example, they may offer an opportunity to reinvigorate regional economies by introducing new goods or services or adopting innovative technologies (Desmet and Rossi-Hansberg, 2009). This relates to the capacity of local stakeholders for responding to a negative event in a transformative and creative way, generating positive outcomes. That is, local actors could use the crisis as an opportunity to promote changes for the better.

Shocks and stresses may have **extreme, medium or everyday intensity**. Extreme disasters are large-scale, sudden and powerful events, such as unexpected volcanic eruptions or earthquakes that affect whole societies (United Nations, 2017a). Medium-intensity disasters, such as tropical storms and power outages, occur more periodically. They may emerge suddenly or gradually over time, as droughts and epidemic diseases do (United Nations, 2017a). For instance, industrial structural change may happen gradually and imperceptibly, and is recognised as a major event when the process reaches a critical level. Everyday hazards are the risks to which people are subject to on a daily basis, such as hygiene risks due to lack of sewage in environmentally fragile urban settlements. The urban poor are especially susceptible to everyday hazards. Although not extreme, these everyday events are also dangerous. In the end, shocks and stresses across different intensities should be considered in the policy-making process.

The social construction of risk

The definition of a situation as risky depends on how social actors frame risks. That is, risks are framed differently according to the different perceptions of social actors and contexts from which they speak. This includes public authorities. Governing risks is a task that begins by framing certain events as risks: when certain events or conditions start to be seen as "risks" by the public and/or the authorities, reduction and prevention become valid and necessary policy goals.

To illustrate, car accidents were long blamed on "drunk" or "careless" drivers (Gusfield, 1981). When car accidents started to be perceived as "risks", they changed from being framed as individual tragedies that were to be avoided if drivers were more responsible to become a collective responsibility. Under this view, auto companies ought to build safer cars. Governmental authorities ought to improve and maintain the quality of roads, monitor speed and provide adequate signalling. Car accidents are now measured and quantified. Because of the social construction of car accidents as a risk, reducing them has become a legitimate governmental goal (Gusfield, 1981).

What is more, risk and vulnerability are dynamic. For one, actual risks change over time. Small- or large-scale disasters, more or less disruptive, can take place more or less often. A city or community is subject to disasters of different intensity levels over time, and because of that risk levels vary. Furthermore, the perception of risks changes over time, as the example of car accidents showed. In the end, risk levels are continually in flux because risk is also a product of how social actors behave.

Box 1 highlights the complex origins of disasters and the social construction of risk. Regarding the origins of disasters, it stresses the social, political and economic processes behind disease epidemics and violence outbreaks in the city of New York in the 1970s. Concerning the social construction of risk, Freudenberg and colleagues (2006) explain that, because local authorities did not perceive these situations as risks at the time, they favoured budgetary cuts over an integrated response to the crisis, incurring human and economic losses.

Box 1. The complex origins of a "syndemic" in New York City

In 1975, New York City experienced a fiscal crisis rooted in long-term political and economic changes in the city. Since the city was on the verge of bankruptcy, it was forbidden to borrow money from public credit markets. In order to balance the municipal budget, an emergency board mandated cuts in city services, reductions in the city workforce and tax increases. Agencies with health responsibilities were particularly hard hit: 7 of 20 district health centres were closed, all 50 community-based clinics were closed and substance abuse treatment was progressively transferred to the state level. City agencies that affected health indirectly were also cut. The police department lost 20% of its workforce, and the narcotics squad was cut by 33%.

Together with these municipal and federal policy decisions, broader social and economic changes such as deindustrialisation, loss of manufacturing jobs, suburbanisation and, two economic recessions contributed to the deterioration of the living conditions for the city's low-income population. Between 1970 and 1980, the number of poor people in New York City increased by 20%, even as the city's population declined by 10%. Subsequently, epidemics of tuberculosis and human immunodeficiency virus (HIV), as well as homicide, hit the city. They formed a syndemic, i.e. three epidemics combined to create an excess disease burden on the local population.

Tuberculosis (TB) rates began to rise in 1978 and did not fall until 1993. Contributing to the resurgence of TB were the fiscal crisis reductions in safety-net programmes such as public assistance and Medicaid and the post-1980 reductions in federal support for low-income housing that pushed many people into homelessness. Between 1982 and 1992, the city's homeless population grew from 7 584 to 23 494, forcing many people into the city's homeless shelters and jails, settings associated with TB transmission. Earlier cuts in hospital services led to overcrowded and understaffed hospitals, which also contributed to the transmission of TB.

By the late 1980s, it was estimated that about 200 000 New York City residents were infected with HIV. Forty-one per cent of HIV cases were related to injection drug use, compared with 25% nationally, making the city's response to drug addiction especially important. The most significant decision was to turn over responsibility for drug treatment to a state government that historically had not been the most proactive actor in this matter. By 1985, there were 250 000 drug addicts in New York City, of whom 30 000 were in treatment and 1 500 on waiting lists for treatment. Furthermore, because most health educators had been laid off, the city lacked the means to communicate health information effectively and credibly. New York City did not implement a comprehensive school-based HIV prevention programme until 1992.

Homicide rates rose in the city in the late 1970s and began to decline in 1991, finally falling below the 1975 level in 1993. Most observers agree that the emergence of crack cocaine in the early 1980s contributed significantly to the increasing levels of violence. The relationships between policing and crime are complex, but the dismantling of substantial portions of the police department without implementation of other public safety programmes contributed to a cycle of escalating crime and reduced community capacity to control drug addiction.

In summary, a variety of policy decisions made during the fiscal crisis and thereafter contributed to the TB, HIV and homicide syndemic in New York City. The actions taken to structurally adjust the city's budget by balancing revenues and expenses had the unintended

consequence of imposing new burdens on the city's poorest residents. Although each of the three epidemics had its own dynamics, city, state and federal decisions about drug treatment, primary healthcare and housing worsened all three, and the policy-driven deterioration in living conditions expanded the size of the populations most vulnerable to these health problems. The costs incurred in controlling these epidemics exceeded USD 50 billion (in 2004 USD); in contrast, the overall budgetary savings during the fiscal crisis was USD 10 billion.

To conclude, this syndemic of tuberculosis, HIV and homicide exemplifies the complex origins of social risks. Health epidemics are not simply natural, but deeply rooted in social, political and economic processes. Beyond the transmission of a virus and individual behaviours judged "careless" or "morally ambiguous", institutional, fiscal and economic aspects of city governance play an important role, too. Furthermore, peaks in urban violence may not be simply taken as a manifestation of social forces, but linked to health treatment issues, institutional responses to previous crises and larger economic stresses.

Source: Freudenberg, N. et al. (2006), "The impact of New York City's 1975 fiscal crisis on the tuberculosis, HIV, and homicide syndemic", http://dx.doi.org/10.2105/AJPH.2005.063511.

1.2. The concept of urban resilience

Resilience is a technical term whose origin can be traced to biology and ecosystem sciences. In the 1970s, contributions such as the one by Holling (1973) emphasised the persistence of ecological systems to changes and their capacity to absorb change without dramatic alteration. Resilience in this sense is a "measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling, 1973: 14).

From this origin, the concept was borrowed by the social sciences. According to cultural ecology, societal systems are akin to ecological ones: "Resilience is a systems concept, and the social-ecological system, as an integrated and interdependent unit, may itself be considered a complex adaptive system." (Berkes and Ross 2013: 14, as quoted in Alexander, 2013: 2 712). That is why principles of ecological systems can be applied to understand the functioning of societies.

This line of thought propagated to psychology, geography, sociology and planning studies (Alexander, 2013). Psychology, for instance, refers to resilience as the means by which individuals can cope with shocks and stresses. Today, the term has been mostly used in climate change adaptation, sustainability science, disaster risk reduction, poverty reduction and increasingly in economics and planning studies (Alexander, 2013; Meerow, Newell and Stults, 2016). The three main approaches to resilience are the socio-ecological, the sustainable livelihoods and the disaster risk reduction (DRR) approaches (Schipper and Langston, 2015).

As of today, meanings and definitions of "resilience" proliferate – not all of them very precise or concise. This proliferation has led scholars to affirm that "the term has not been well defined … existing definitions are inconsistent and underdeveloped" (Meerow, Newell and Stults, 2016: 38).[2] There are around 25 different definitions of "urban resilience" in the academic literature, coming mostly from environmental and social sciences (Meerow, Newell and Stults, 2016). Several other definitions of "urban

[2] Comparative tables of definitions can be found in Stein (2013); Winderl (2014); and Meerow, Newell and Stults (2016), to mention a few.

resilience" have been advanced in the policy-advising international arena as well (Table 3).

Table 3. Definitions of urban resilience

Institution	Definition
UN-Habitat	Resilience refers to the ability of any urban system to withstand and to recover quickly from multiple shocks and stresses and maintain continuity of service.
International Council for Local Environmental Initiatives (ICLEI)	A city that is prepared to absorb and recover from any shock or stress while maintaining its essential functions, structures and identity as well as adapting and thriving in the face of continual change. Building resilience requires identifying and assessing hazard risks, reducing vulnerability and exposure, and lastly, increasing resistance, adaptive capacity and emergency preparedness.
United Nations Office for Disaster Risk Reduction (UNISDR)	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.
Rockefeller Foundation	Resilience is the capacity of individuals, communities and systems to survive, adapt and grow in the face of stress and shocks, and even transform when conditions require it.
Resilientcity.Org	A resilient city is one that has developed capacities to help absorb future shocks and stresses to its social, economic and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems and identity.
World Bank	Resilience is characterised by the ability of people, societies and countries to recover from negative shocks, while retaining their ability to function.
USAID	Resilience is the ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth.
100 Resilient Cities	Urban resilience is the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow regardless of what kinds of chronic stresses and acute shocks they experience.
Resilient Europe	Urban resilience is the capacity of urban systems, communities, individuals, organisations and businesses to recover, maintain their function and thrive in the aftermath of a shock or a stress, regardless its impact, frequency or magnitude.
Global Alliance for Resilience (AGIR)	The capacity of vulnerable households, families, communities and systems to face uncertainty and the risk of shocks, to withstand and respond effectively to shocks, as well as to recover and adapt in a sustainable manner.

Source: ICLEI (2015), *ICLEI Resilient Cities Agenda 2015*. http://www.iclei.org/activities/agendas/resilient-city.html; Resilient Europe (2016), *Ready for the future? Urban resilience in practice*, http://urbact.eu/ready-future-urban-resilience-practice; Jha, A.K., T.W. Miner and Z. Stanton-Geddes (eds.) (2013), *Building Urban Resilience: Principles, Tools, and Practice*, http://dx.doi.org/10.1596/978-0-8213-8865-5; AGIR Global Alliance for Resilience (2013), "Regional roadmap", https://www.oecd.org/swac/publications/AGIR%20roadmap_EN_FINAL.pdf.

In all, these definitions have important elements in common. They treat resilience as a **capacity** – i.e. a positive attribute that can be built and acquired – by cities, communities, households, organisations or businesses. This capacity comprises certain actions, such as resist, absorb, adapt, transform, change, recover and prepare, in relation to certain events (shocks, stresses, hazards, disasters) or the possibility of them taking place (risks).

This paper builds upon previous OECD work on the concept of resilience. The OECD has been concerned with resilient economies and societies, risk governance issues, and more recently with a holistic, territory-based view of resilience (Box 2). Bearing that in mind, and for the purposes of this work, **urban resilience** can be understood as the ongoing capacity of cities to absorb, adapt, transform and prepare for shocks and stresses along the economic, social, institutional and environmental dimensions, with the aim of maintaining the functions of a city and improving response to future shocks.

Box 2. How "resilience" has been discussed in the OECD

1. The OECD's 2014 Ministerial Council Meeting concluded its discussion on the importance of "resilient economies and inclusive societies" with the following statement (OECD, 2014j):

…We discussed how we can achieve "**resilient economies and inclusive societies**" to generate jobs and growth, empower people and promote the well-being of our citizens. We share a common goal of increasing resilience of our economies by incorporating multidimensionality into policy design to help identify trade-offs, complementarities and unintended consequences of policy choices. Sound and appropriate macroeconomic management including responsible fiscal policies, further structural reforms and further global rebalancing are all essential for achieving robust, resilient and inclusive growth, taking into account rising inequality.

… Rising inequality endangers social cohesion and weakens social resilience, thereby hampering economic resilience. A key challenge is to achieve inclusive growth by providing social protection and empowerment to people, which can strengthen human security. Appropriate flexibility and security in labour markets, and relevant education and skill programmes, can facilitate greater inclusion and participation of under-represented groups. We welcome OECD initiatives targeting these groups, including on gender equality, youth employment, ageing society and the integration of migrants. We also recognise that regional and urban policies can play a key role in empowering people and building resilience at all levels of our economies and societies.

2. The 2015 Ministerial Council Meeting concluded its discussion about resilience by underlining the importance of structural reforms to improve growth prospects, boost employment and strengthen economic resilience, and by stating the growing role of cities in fostering entrepreneurship to promote a more resilient and sustainable economy and society (OECD, 2015c)

3. The "Overview paper on resilient economies and societies" (OECD, 2014a), summarised the definition and the scope of the concept of resilience as follows:

The 2008 economic and financial crisis highlighted the importance of strengthening the resilience of our economies, societies and institutions. Resilience is a broad concept, centred on the ability not only to resist and recover from adverse shocks, but also to "bounce back" stronger than before, and to learn from the experience. Resilience is also multidimensional, encompassing a range of interconnected factors and conditions. Strengthening resilience is all the more essential today in the face of increasing policy complexity and interconnectedness, deep-seated demographic and technological trends, and growing environmental pressures, all of which increase the likelihood of some critical event having negative impacts on economic growth and well-being.

4. Economic resilience is further discussed in the light of indicators in the paper *"Economic resilience: A new set of vulnerability indicators for OECD countries"* (Röhn, O. et al. 2015). The paper presents the source and nature of potential vulnerabilities in OECD countries that can lead to costly economic crises. Based on recent early warning literature and lessons learned from the global financial crisis, it proposes a dataset of more than 70 vulnerability indicators that could be monitored to assess countrywide risks in OECD economies. Evidence shows that the majority of the proposed indicators are helpful in predicting severe recessions and crises in the 35 OECD economies between 1970 and 2014.

5. Territorial resilience was discussed in *How's Life in Your Region? Measuring Regional and Local Well-being for Policy Making* (OECD, 2014g). In assessing the sustainability of

regions' well-being, this study defined territorial resilience as the capacity of territories or communities to absorb the effects of shocks and learn from them in order to move forward. Resilience of a region refers to the adaptability of a territory, which includes the capacity of its individuals and firms to deal with upsets, and the capacity of institutions to adapt and reform. At the same time, the resilience of a region is diminished by its vulnerability, that is to say, the potential impact of the shock on the community. Vulnerability results from exposure and sensitivity to shocks.

Other OECD studies have also focused on resilience at the regional level. A study of the region of Abruzzo in Italy, after the L'Aquila earthquake, defined resilience as the ability to withstand and to recover from external, adverse shocks through adjustment processes that re-establish or enhance the previous state of the system (OECD, 2013). This study was particularly important in highlighting the need to strengthen resilience through an integrated regional development strategy, and in building a framework to assess resilience. It also pointed out that the quality of the public and private sectors is a key aspect of determining resilience at the regional level.

6. The issue of economic and social resilience was further elaborated, from the perspective of risk governance, at the OECD High-Level Risk Forum (OECD, 2014h). Resilience was defined as the ability of social and economic systems to maintain function when shocked and while in recovery. The Forum underlined the importance of forward-looking risk governance, the role of trust, and an optimal and complementary mix of resilience measures. It also acknowledged the importance of institutions and civil society actors in making risk measures effective.

In addition, the perspective of risk governance and disaster risk management had already been discussed at a G20 / OECD methodological framework (2012). G20 Finance Ministers and Leaders have recognised the importance and priority of adequate DRM strategies: "We recognize the value of Disaster Risk Management (DRM) tools and strategies to better prevent disasters, protect populations and assets, and financially manage their economic impacts" (Los Cabos, 19 June 2012).

In relation to that, the OECD (2014e) has developed a governance tool, the **Resilience Systems Analysis (RSA) framework**, to assess state fragility. It aims at building a shared understanding of the main risks (conflicts, natural disasters, disease, economic shocks etc.) in a given context as well as the existing capacities within those societies to cope with such risks. The analysis can identify gaps in programming and develop a 'roadmap' to boost resilience – namely determine what should be done, by whom and at which level of society. The RSA helps to highlight where people are vulnerable and to better identify priorities for strengthening the assets of poor and marginalised groups.

Sources: G20 / OECD (2012), *Methodological Framework for Disaster Risk Assessment and Risk Financing*, http://www.oecd.org/gov/risk/G20disasterriskmanagement.pdf; *OECD* (2013), *Policy Making after Disasters: Helping Regions Become Resilient – The Case of Post-Earthquake Abruzzo*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264189577-en;; OECD (2014a), "Overview paper on resilient economies and societies", www.oecd.org/mcm/C-MIN(2014)7-ENG.pdf; OECD (2014e) *Guidelines for resilience systems analysis*; OECD (2014f), "Resilient economies and inclusive societies – Empowering people for jobs and growth: 2014 Ministerial Council Statement", www.oecd.org/mcm/2014-ministerial-council-statement.htm; OECD Publishing OECD (2014g), *How's Life in Your Region? Measuring Regional and Local Well-being for Policy Making*, http://dx.doi.org/10.1787/9789264217416-en; OECD (2014h), *Recommendation of the Council on the Governance of Critical Risks*, OECD, Paris, available at: www.oecd.org/gov/risk/Critical-Risks-Recommendation.pdf; OECD (2015c), "Unlocking investment for sustainable growth and jobs: 2015 Ministerial Council Statement", www.oecd.org/mcm/documents/ministerial-council-statement-2015.htm; Röhn, O. et al. (2015), *"Economic resilience: A new set of vulnerability indicators for OECD countries"*, OECD Economics Department Working Papers, No. 1249, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jrxhgjw54r8-en.

1.2.1. Resilience needs to be articulated at the global, national and local scales

Resilience can be referred to at the scale of a country, region, urban area, city, community or household (Table 4). This distinction matters to policy makers because the scale at which resilience is framed reflects the privileged arena for debate and action (Box 3 below). Each of the three main approaches to resilience (socio-ecological, disaster risk reduction and sustainable livelihoods) prefers one scale over the other. Yet these approaches are not mutually exclusive but complementary, meaning e.g. that action at the local level must be complemented by national policy frameworks.

Table 4. The three main approaches to resilience

Approach	Sample definition of resilience	Typical scale of analysis	Most commonly adopted concepts
Disaster risk reduction	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. (United Nations, 2017a)	Global and national	Hazard Disaster Disaster risk
Socio-ecological	The amount of change the system can undergo and still retain the same controls on function and structure; the degree to which the system is capable of self-organisation; and the ability to build and increase the capacity for learning and adaptation. (Holling and Walker, 2003)	Cities and communities	Shocks Stresses
Sustainable livelihoods	A capacity that enables households and communities to maintain a minimum threshold condition when exposed to shocks and stresses. (Frankenberger et al., 2014)	Households and communities	Vulnerability

Sources: Schipper, E.L.F. and L. Langston (2015), "A comparative overview of resilience measurement frameworks", https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9754.pdf; World Bank (2015), "CityStrength diagnostic methodological guidebook", http://documents.worldbank.org/curated/en/557791467992483926/pdf/AUS7942-REVISED-ESW-PUBLIC-Box382167B.pdf; and own elaboration.

Disaster risk reduction approaches typically prioritise actions and plans at the national scale. The Sendai Framework grants the national level a primary role in DRR strategies (see Annex 1). It instructs that national governments should elaborate plans and invest resources to promote resilient nations. Examples of national-level measurements are the Risk Reduction Index, the Country Resilience Rating and the Prevalent Vulnerability Index (Winderl, 2014).

The city scale is emphasised by the socio-ecological approach. The city is seen as a complex socio-ecological system, as in ICLEI (2015) and Arup and Rockefeller Foundation (2015). "Systems thinking" offers a "holistic" view of cities, stressing the dynamism of change and inter-connection between the multiple elements of the system: "cities are adaptive, socio-technical systems comprising various elements which, when combined, have qualities that may not be present individually. Changes are systemic (i.e. changes in one element of the system may induce changes in another element), and dynamic (the result of feedback loops)" (Silva, Kernaghan and Luque, 2012: 5). In this sense, analysing the resilience of cities requires a holistic, whole-of-system approach.

The sustainable livelihood approach, as the ones adopted by the Food and Agriculture Organization (FAO) and Oxfam (Jennings and Manlutac, 2015), privileges the

household level. The well-being of individuals and families is considered the basic building block for resilience. This approach is compelling for countries in which levels of poverty and social inequality are high. Extensive research has proved that one of the main determinants of vulnerability is individual wealth (Jennings and Manlutac, 2015). Poor households tend to live in more fragile areas, have less means of sustaining themselves in case of disaster, and suffer from poorer health and poorer access to services and jobs. These factors translate into higher vulnerability levels, which justifies the focus on improving households' livelihood conditions.

In between the city- and the household scale, some frameworks advocate a community-based approach to resilience (Cutter, Ash and Emrich, 2014; USAID, 2016). Socio-spatial segregation and inequality create very different levels of vulnerability and resilience within the urban fabric. Particularly, poorer communities are more fragile in socio, economic and environmental terms (Hillier and Castillo, 2013). The city-wide systemic approach may overlook the fact that different areas and population groups have different vulnerability and resilience levels. In contrast, the community-oriented approach shines light upon intra-urban disparities and inequalities.

The community-oriented approach stresses the importance of social cohesion and local institutions. The well-documented case of the Chicago heat wave (1995) shows that communities with higher local interaction and sociability levels can respond better to disasters, in comparison with communities of similar economic conditions but weaker social networks (Klinenberg, 1999). This approach also emphasises the importance of assessing perceptions in resilience metrics. For instance, beyond homicide rates, local authorities should also measure how safe individuals *feel* in their neighbourhoods. Another example is the Corruption Perceptions Index, in which the opinion of experts and authorities is used to define how corrupt a country is.

Approaches at different scales complement each other. To illustrate, regarding vulnerability to floods, a sustainable livelihood approach would focus on addressing irregular occupation of flood-prone areas. City-wide measures, such as designing a flood plan and creating a monitoring agency, would be complementary to this household-based approach. Improving or installing adequate sewage disposal systems, whose absence often undermines infrastructural capacity to absorb rainfall, is another approach at the city scale that directly impacts households.

In addition to these different scales, **individual action** is also fundamental to resilience-building. The success of awareness-raising initiatives depends on the engagement level of individuals. Training sessions in public schools, informative sessions at the workplace campaigns, rallies and the like are tools that cities can use to increase citizen awareness to disaster risks. Empirical evidence confirms that awareness training programs can raise preparedness levels and positively influence hazard-related cognition among participants (Karanci, Aksit and Dirik, 2005).

Since resilience at one scale complements and enhances the other scales, **all scales matter (Box 3)**. If it is true that speaking of a "resilient country" seems too generic, on the other hand it is at the national level that disaster risk frameworks can be drawn, which can in turn influence local governments. In a similar sense, placing the responsibility for enhancing resilience in the hands of households alone may mask the broader institutional, social, economic and political factors behind resilience-building, which require the support of governmental authorities. Lastly, a more community-oriented approach in resilience-building may bridge intra-urban disparities, overcoming the pitfalls of speaking of cities as integrated units.

Box 3. Institutional trends in urban resilience

- The United Nations Development Programme (UNDP) published in 2012 the *Community-Based Resilience Analysis* tool, with the aim of measuring and identifying the key building blocks of community resilience, as well as assessing various humanitarian interventions in attaining these characteristics.
- The United Nations Office for Disaster Risk Reduction (UNISDR) *Making Cities Resilient Campaign* (2010-) supports sustainable urban development by promoting resilience activities and increasing local understanding of disaster risk (UNISDR, 2013).
- UN-HABITAT's *City Resilience Profiling Program* (2012-) provides national and local governments with tools for measuring and increasing resilience to multiple hazards, including those associated with climate change. In 2016, it became a pillar of the agency-wide Urban Resilience Programme (URP). The URP organises projects and activities across the pillars of technical cooperation, advocacy and knowledge diffusion.
- The World Bank launched in 2013 the *Resilient Cities* Program, a multi-year initiative to help cities increase their ability to prepare for and adapt to changing conditions, as well as to withstand and recover rapidly from disruptions related to climate change, natural disasters and other systemic shocks. In 2016, the World Bank published – in collaboration with the partnership *Global Facility for Disaster Reduction and Recovery* – the report *Investing in Urban Resilience: Protecting and Promoting Development in a Changing World*.
- The Rockefeller Foundation's *City Resilience Index* (2016) provides principles, indicators and practices to assess and promote resilience, highlighting the importance of a comprehensive and holistic framework to enhance the function of cities in a system.
- The *100 Resilient Cities* programme was launched in 2013 by the Rockefeller Foundation, with the support of a broad network of global partners. The programme assists cities in developing new resilience strategies and supports the hiring of a Chief Resilience Officer for each participating city.
- ICLEI – *Local Governments for Sustainability* has an overarching programme for urban resilience, *Resilient Cities*, which covers issues surrounding climate change mitigation and adaptation, disaster risk reduction and food security. The programme produces a range of conferences, seminars, networks, tools and guidebooks to inform and learn from leaders about resilience-building efforts at all government levels.
- The European Commission launched in 2016 the *RESCCUE Project* – RESilience to cope with Climate Change in Urban arEas: a multi-sectoral approach focusing on water. It aims at helping cities around the world to face physical, social and economic stresses or shocks, taking the water sector as its entry point to urban systems.
- The European Spatial Planning Observation Network's (ESPON) (2014) identified different levels of economic recovery in 1 322 European regions after the 2008 crisis. ESPON provided a methodology to classify regions according to their recovery scenarios. GDP and total employment data were used as the most robust indicators for identifying the socio-economic resilience of regions.

Sources: UN-Habitat (2017), *Trends in Urban Resilience ;* ESPON (2014), *ECR2 Economic Crisis: Resilience of Regions,* www.espon.eu/main/Menu_Projects/Menu_AppliedResearch/ECR2.html; UNISDR (2013), "Making cities resilient: Summary for policymakers. A global snapshot of how local governments reduce disaster risk – April 2013", www.unisdr.org/files/33059_33059finalprinterversionexecutivesu.pdf.

The qualities of resilient cities

There has been a **shift from equilibrist resilience to evolutionary resilience**. While Holling (1973) stressed the dimension of stability, more recent accounts added notions of evolution and transformation to resilience (White and O'Hare, 2014). Considering that the previous state contributed to the occurrence of the shock in the first place, returning to it may not be resilient. Resilient cities would achieve an improved, new state of normality after the shock or stress (White and O'Hare, 2014). In short, the emphasis has shifted from stability to adaptation and change.

With this shift, three cumulative pathways to a resilient state emerged: persistence (resist disturbance and maintain the status quo), transition (incremental adaptation) and transformation (change) (Meerow, Newell and Stults, 2016). These relate to three capacities of resilient systems: **absorptive coping, adaptive and transformative capacity** (Béné et al., 2012) (Table 5).

Table 5. Cumulative pathways to resilience

Intensity of change/transaction costs →		
Stability	**Flexibility**	**Change**
Absorptive coping capacity	Adaptive capacity	Transformative capacity
Persistence of the system to resist to shocks and return to stability quickly	*Incremental adjustment and adaptation* to changing circumstances	*Transformational responses* that alter the system in significant manners, evolving into a new, better state
Resilience ↔		

Source: Béné, C. et al. (2012), "Resilience: New utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes", http://dx.doi.org/10.1111/j.2040-0209.2012.00405.x.

Resilience frameworks expanded this understanding, making the "action" of resilience more precise and complete. The Rockefeller Foundation (2016) presents seven "qualities" of resilient cities: ability to learn (reflective); limit the spread of failure (robust); can easily repurpose resources (resourceful); has alternative strategies (flexible); has backup capacity (redundant); includes broad consultation and communication (inclusive); and has systems working together (integrated). It represents a shift from short-term post-disaster responses to a more complete process of prevention, response, consultation and monitoring that is itself a continuous loop.

Table 6. The qualities of resilient cities

Time/phase emphasis	Quality (or capacity)	Description
Prevention preparedness/ pre-existing conditions	**Robust**	The system has well-designed, constructed and managed physical assets to absorb shocks without significant damage or loss of function.
	Redundant	The system intentionally has spare capacity to accommodate unexpected needs, disruptions and surges in demand, in a cost-effective manner.
Response recovery/ outcome-oriented	**Flexible**	The system can adopt different, alternative solutions, in response to changing circumstances.
	Resourceful	People and institutions are able to rapidly find different ways to meet critical needs with the available resources.
	Reflective	The system can examine and systematically learn from past experiences, to inform future decision making that will enable adaptation and change.
Building together/ process-oriented	**Inclusive**	The system promotes broad consultation and engagement of different actors in the process of building resilience, as to bring diverse perspectives together.
	Integrated	The process of building resilience works across different scales, levels of government and types of risks, bringing perspectives together to reach a common outcome.

Source: Arup (2015), City Resilience Index (2016) and own elaboration.

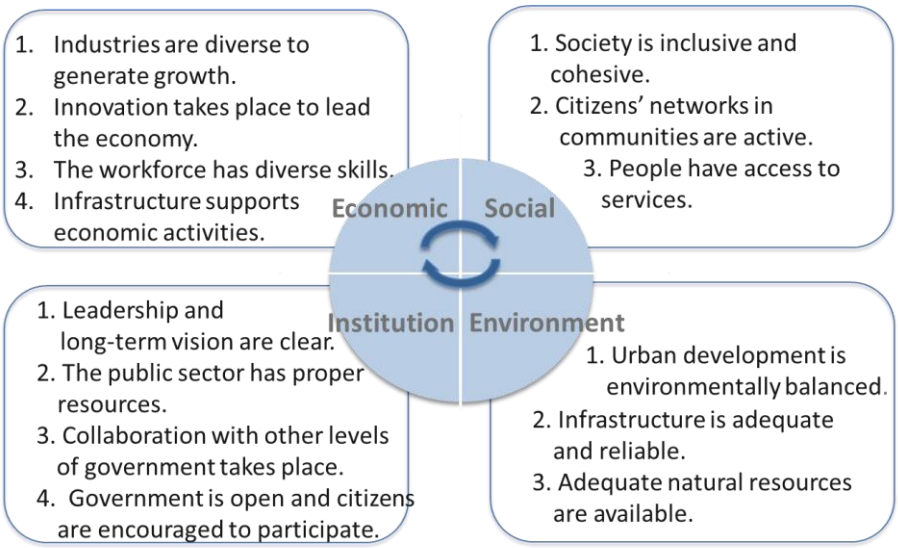
In all, the seven qualities enhance resilience-building in an overarching manner. More than recovering from shocks and stresses, a city ought to transition, transform and change to a better, stronger state. It should do so by counting on strong backup capacity (redundant), while being flexible to envision and adopt different strategies (flexibility and resourcefulness). The policy-making process also gains importance: opening up to popular participation, being transparent, and integrating different sectors and agents are all elements of inclusive and integrated resilience-building.

By understanding **resilience as a multi-dimensional, complex capacity**, cities enlarge their field of action. This enlarged field of action means that cities face a bigger challenge ahead of them, regardless of the path they choose. If focusing solely on the process, the city may become inclusive and integrated, but without the adequate infrastructure it will not be robust. The different qualities are not successive stages but parallel tracks of action. In this sense, one quality may be achieved before the other, without any particular order. While they do not depend on one another, they are mutually reinforcing and co-constitutive of overall greater resilience.

1.3. The dimensions of resilience

Four drivers of resilience, identified by the OECD Ministerial Council's statement (OECD, 2014a), serve as the foundational structure for this framework. The **economic** dimension calls for industry diversification and room for innovation. The second is **social**: ensuring that society is inclusive and cohesive, citizen networks are active and people have access to opportunities. The third is **environmental**: if urban development is sustainable; if adequate and reliable infrastructure is available; and if adequate natural resources are available. Lastly, **institutional** aspects require clear leadership and long-term vision; sufficient public resources; collaboration with other levels of government; and an open and participatory government.

Figure 1. Resilience framework



Source: OECD (2016), "Resilient cities" (for internal consultation only).

Economy

This dimension refers to the economic conditions of a city or community, as in employment levels, the diversification of the economic base, the number of businesses, the disposable household income and other factors. It also relates to overall exposure in global economic value chains. Resilient cities have diversified industries and potential for innovation (OECD, 2014a). Reliable infrastructure and skilled labour force contribute to enhancing economic resilience, among other factors.

Society

It is the aspect of the well-being of a society and its members, organised or not. This dimension includes the demographic profile of a city or community (age, gender, poverty, etc.), the health conditions, the levels of social capital, civic engagement and effective social ties. Resilient cities are able to cope with shocks by adopting a co-ordinated and coherent set of economic and social policies and practices (OECD, 2014a). In particular, social inclusion and access to jobs and education can help cities address change smoothly.

Environment

Resilience matters in the face of environmental degradation, the overuse of resources and the potential costs of climate change and natural disasters (OECD, 2014a). Complex urban systems are particularly vulnerable to extreme weather events (OECD, 2014d). For example, built-up environments are at greater risk of localised flooding after a heavy storm, which may lead to contamination of the water supply.

This dimension refers to the natural environment and to the systems and networks implemented to manage it. Notably, it includes structures that provide critical services for disaster response and recovery, such as communication, transportation, water and sanitation. Building environmental resilience requires preparedness at the local level to

understand how climate change will impact local communities and to take action to safeguard human well-being and community assets.

Institutions

It refers to the institutions, organisations and decision-making processes that administer a city or community. It involves governments, organised civil society and private stakeholders in the process of risk governance. Capacity includes knowledge sharing, capacity development, learning processes and participatory channels. Institutional capacity is necessary to respond and rebound to shocks (OECD, 2014a).

Resilient institutions ensure open, transparent and inclusive policy making and enable effective policy implementation. In particular, city authorities are on the front line of effective delivery of public services and data and information sharing. Capacity building in local governments and development in human resources are indispensable for resilient institutions that are competent and flexible to change (OECD, 2014c).

The dimensions of resilience need to be co-ordinated

The four dimensions are inter-related. For example, "sustainable urban development" is relevant not only for the environment but also for economic and social resilience. In this sense, isolated policy responses cannot effectively address risks, and responses from different policy sectors should be co-ordinated.

Many, if not most, disasters and risks require coping with all dimensions. To illustrate, in the event of a flood, those in poverty living in inadequate housing may be the hardest hit (social and economic), roads and sanitation systems may be disrupted (built environment), and emergency services must be put in operation (institutional). The fact that floods are a natural disaster does not mean that the resilience strategy should encompass only the infrastructural aspects of flood-resistant structures or road access. In fact, who is affected by the disasters and how to respond to it are social, economic and institutional issues that should be considered in the resilience strategy.

The example of health epidemics is also illustrative of such need for integration. As a disease outbreak affects the health of individuals, the number and the demographic characteristics of those affected by it matter (social). Yet, it is also fundamental to know the sanitary conditions of a place (built environment), the existing health facilities (built environment), the design of health and food safety policies (institution), the location of the city in migration and trade networks (economic), among other factors. A comprehensive, cross-sectoral approach is needed to develop an integrated resilience strategy that can address this challenge.

At the same time, governments act in sectors. In a pragmatic sense, the division in dimensions (Figure 1) facilitates a hands-on approach to resilience. As much as the different sectors should dialogue, they still form separate entities or organisms, with their own budget, policies and area of intervention. If the process of resilience-building follows this logical division, it can be more easily integrated into existing governance schemes. To conclude, an integrated approach to resilience-building is desirable to bridge gaps between sectors, i.e. to co-ordinate action across government departments, not to eliminate them altogether.

2. Governing and measuring: Indicators for resilient cities

2.1. Governing risks: Process and tools

The OECD (2014) has developed a risk governance framework.[3] The main objective of the risk governance process is to create an integrated, multi-risk and participatory strategy to disaster risk. This process includes different steps to understand, prepare for and react to disasters and shocks (Box 4). The different steps may occur in parallel and in a cyclical fashion, not necessarily linearly. For instance, the adoption of structural protection measures does not always precede knowledge-sharing efforts; they may even occur at the same time. Some plans and policies may need to be reviewed or updated, while other steps have already been implemented. The success of the process depends not only on the involvement of different levels of government but also on the engagement of businesses and civil society actors.

Box 4. The risk governance process: Key recommendations

I. Establish and promote a comprehensive, all-hazards and transboundary approach to country risk governance to serve as the foundation for enhancing national resilience and responsiveness.

1. Develop a national strategy for the governance of critical risks.

2. Assign leadership at the national level to drive policy implementation, connect policy agendas and align competing priorities across ministries and between central and local governments.

3. Engage all government actors at national and subnational levels, to co-ordinate a range of stakeholders in inclusive policy-making processes.

4. Establish partnerships with the private sector to achieve responsiveness and shared responsibilities aligned with the national strategy.

II. Build preparedness through foresight analysis, risk assessments and financing frameworks, to better anticipate complex and wide-ranging impacts.

1. Develop risk anticipation capacity linked directly to decision making.

2. Equip departments and agencies with the capacity to anticipate and manage human-induced threats, criminal and terrorist networks.

3. Monitor and strengthen core risk management capacities.

4. Plan for contingent liabilities within clear public finance frameworks by enhancing efforts to minimise the impact that critical risks may have on public finances and the fiscal position of a country in order to support greater resilience.

[3] The OECD framework, originally designed for the national level, can be easily adapted to subnational governments.

III. Raise awareness of critical risks to mobilise households, businesses and international stakeholders and foster investment in risk prevention and mitigation.

1. Encourage a whole-of-society approach to risk communication and facilitate transboundary co-operation using risk registries, media and other public communications on critical risks.

2. Strengthen the mix of structural protection and non-structural measures to reduce critical risks.

3. Encourage businesses to take steps to ensure business continuity, with a specific focus on critical infrastructure operators.

IV. Develop adaptive capacity in crisis management by co-ordinating resources across government, its agencies and broader networks to support timely decision making, communication and emergency responses.

1. Establish strategic crisis management capacities to prepare for unknown and unexpected risks that provoke crises.

2. Strengthen crisis leadership, early detection and sense making capacity, and conduct exercises to support inter-agency and international co-operation.

3. Establish the competence and capacities to scale-up emergency response capabilities to contend with crises that result from critical risks.

4. Build institutional capacity to design and oversee recovery and reconstruction plans.

V. Demonstrate transparency and accountability in risk-related decision making by incorporating good governance practices and continuously learning from experience and science.

1. Ensure transparency regarding the information used to ensure risk management decisions are better accepted by stakeholders to facilitate policy implementation and limit reputational damage.

2. Enhance government capacity to make the most of resources dedicated to public safety, national security, preparedness and resilience.

3. Continuously share knowledge, including lessons learnt from previous events, research and science post-event reviews, to evaluate the effectiveness of prevention and preparedness activities, as well as response and recovery operations.

Source: OECD (2014), *Recommendation of the Council on the Governance of Critical Risks*, www.oecd.org/gov/risk/Critical-Risks-Recommendation.pdf.

Risk governance is about governing disaster risk, beyond merely reacting to disasters. This means that stakeholders should prepare for disaster risk in the policy-making process even if a disaster does not actually occur. For instance, early-warning systems should be ready to operate in the event of a disaster. If the disaster does not take place, the systems would not be activated, yet they would still exist and matter.

Planning and management as risk governance tools

Mitigation and preparedness are of fundamental importance in the risk governance approach. Risk assessment, hazard mapping, risk-based land-use planning, financing

and transfer mechanisms are tools of mitigation and preparedness (Table 7). Tools such as early-warning systems, training, awareness-raising and food stocking also have to be ready before a disaster hits. The risk governance process includes capacity-building to enable better recovery and reconstruction in the future, too. For instance, retrofitting and post-event reviews can only take place after a disaster, but these capacities should be learnt beforehand. Therefore, many of the tools of the risk governance process have to be in place before a disaster hits.

Table 7. The main tools of the risk governance process

Risk assessment	Risk assessment is a tool of risk management that informs about previous disaster events and estimates the impacts of future shocks. This detailed record-keeping helps city leaders to identify the risks that the city is most often subject to, at which frequency, in what territories and at what levels of loss. It also aims at better predicting the future, by quantifying the probability and impacts of hazards.
Risk-based land-use planning	Risk-based land-use planning is a non-structural approach that identifies the safest locations and regulations for guiding urban development. Land-use plans influence the location, type, design, quality and timing of development. The plan is a reference for taking decisions about ordinances and permits, as well as allocating finances.
Emergency response plan	Emergency response plans have both operational and logistical components, including procedures for damage and needs assessment after a disaster. An emergency response plan should identify patterns for stakeholder co-ordination, both horizontally with local actors and vertically with regional and national authorities.
Early-warning system	An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.
Urban ecosystem management	Ecosystem management approaches make use of natural infrastructure and can decrease the cost of urban infrastructure projects. Watershed management, coastal zone management, urban landscape design, green and blue infrastructure and environmental buffers are examples of relevant ecosystem management strategies. Integrating ecosystem services into urban resilience planning requires that planners raise awareness of ecological approaches, generate useful information, turn knowledge into action, and effectively monitor and evaluate project implementation.
Data collection	Promoting data accessibility is an important component of any technical disaster or climate risk project. To ensure sustainability of project results, all data collected and created should be preserved, consolidated and transferred to stakeholders upon project completion in a well-known or standard electronic format.
Training and awareness	Capacity development is the process by which people, organisations and society systematically stimulate and develop their capacities over time to achieve social and economic goals. It involves learning and various types of training, but also continuous efforts to develop institutions, political awareness, financial resources, technology systems and the wider enabling environment.
Community and stakeholder participation	Participation of communities and other stakeholders in urban programming and planning initiatives enhances urban resilience. It is vital to ensure that vulnerable and marginalised populations are full and meaningful participants in all processes. It can also be fostered via multi-sector and multi-level partnerships with government and civil society, including community-based organisations, the private sector and academia.
Risk financing	Disaster risk financing and insurance instruments can protect against the financial impacts of natural disasters but do not reduce the amount of damage and loss. Risk retention, risk financing and risk transfer instruments should be selected to cover disasters of different frequency and severity. Examples of instruments are risk pools, reserve funds, weather derivatives, indemnity-based reinsurance, parametric insurance and catastrophe bonds.

Source: Adapted from: Jha, A.K., T.W. Miner and Z. Stanton-Geddes (eds.) (2013), *Building Urban Resilience: Principles, Tools, and Practice*, http://dx.doi.org/10.1596/978-0-8213-8865-5.

The tools of the risk governance process (Table 7), notably risk assessment, risk-based land-use planning, early-warning systems and strategies of ecosystem management, should be periodically updated. They should contain the most recent data, including demographic and infrastructure databases and detailed information on hazardous events or disasters. The process of design and implementation of these tools should be participatory, inclusive and open. This all is justified by the need to accurately predict the city's situation in order to inform policy-making.

Multi-risk assessments: Towards a territorial approach to risk

Urban policy makers should promote participatory multi-risk assessments. This tool assesses the risks to which a given territory and its population is or may be susceptible, together with the interactions among these risks (Komendatova et al., 2016). It represents a methodological shift from single-risk, expert-driven assessments. The local level of government is close enough to citizens to enable the necessary participatory efforts in risk assessment.

The transition from single- to multi-risk assessments represents a **territorial-centred perspective to hazards** (Carpignano et al., 2009). The traditional single-risk assessment identifies the source of the hazard first and then defines the impact area and potential effects. In the multi-risk assessment (MRA), the definition of a target area is the first step, followed by inspection of the possible hazard sources (Komendatova et al., 2016). MRA accounts for the risk from several hazards, taking into account the possible interactions among hazards and vulnerability (Gallina et al., 2016).4

The methodological shift to MRA provides a **holistic view of risks**, what contributes to increased awareness of risks and their cascading affects. MRA can allow for better quantification of risks, better planning, and better design of plans and programmes (Komendatova et al., 2016). For instance, practitioners in Guadeloupe affirmed that MRA has led to better understanding of cascading effects of risks in urban infrastructure, enabling better calculation of the evacuation time of injured people in emergency situations (Desramaut, 2013, as cited in Komendatova et al., 2016).

What is more, contrary to single-risk assessments, MRAs may enhance **multi-sector co-operation**. In single-risk analyses, the distribution of different types of risks to different levels of governance may hinder vertical co-operation. For instance, in Italy volcanic risk is a national matter, while flood risk lies under the responsibility of regional governments (Komendatova et al., 2016). Different priorities of agencies in charge of risk management may also hamper horizontal co-operation in resilience-building. To illustrate, while an agency may prioritise early-warning systems against floods, another agency may be in charge of reduction of household vulnerability against earthquakes. As such, communication and strategy alignment between agencies may prove difficult (Komendatova et al., 2016). MRA could improve multi-sector information exchange, communication efforts and integrated responses, fostering co-operation.

Multi-risk assessments emphasise the territory. The territory is the recipient (and producer) of multiple, interconnected risks, and understanding its complexity is the first step for governmental action. Yet the territory needs to be defined. One could say

[4] Several methodologies of multi-risk assessment have been proposed. See Carpignano et al (2009) and Chen et al (2016) on that.

that the territory is the city within its administrative boundaries. However, cities often expand their area of economic and social influence beyond these legal limits. What is more, risks do not respect administrative boundaries. For instance, a fire may spread across several cities; job losses due to an economic shock may affect multiple jurisdictions. For these reasons, the territory should be defined by its functional economic ties, its population density and its commuting flows. The OECD has developed a methodology to identify and measure functional urban areas (Box 5).

Box 5. How to define cities?

The places where people live, work and socialise may have little formal relationship to the administrative boundaries around them; for example, a person may live in one region but work in another and on the weekends practice a sport in a third. Regions interact through a broad set of linkages, such as job mobility, production systems or collaboration among firms. These often cross local and regional administrative boundaries. To take into consideration their economic or social area of influence, cities are defined as functional urban areas.

The OECD-EU definition of functional urban areas consists of highly densely populated urban centres and adjacent municipalities with high levels of commuting (travel-to-work flows) towards the densely populated municipalities. A minimum threshold for the population size of the functional urban area is set at 50 000 inhabitants. The definition is applied to 30 OECD countries (with the exception of Iceland, Israel, Latvia, New Zealand and Turkey), and it identifies 1 197 urban areas of different sizes. Metropolitan areas are defined as the functional urban areas with a population above 500 000. There are 281 metropolitan such areas across OECD countries, corresponding to 49% of total population in 2014.

This approach to functional urban areas has the advantage of providing a methodology that can be applied across the whole OECD, thus increasing comparability across countries, unlike definitions and methodologies created within individual countries, which have been internally focused. In order to establish this cross-country methodology, common thresholds and similar geographical units across countries were defined. These units and thresholds may not correspond to the ones chosen in the national definitions. Therefore, the resulting functional urban areas may differ from the ones derived from national definitions.

Source: OECD (2012), *Redefining "Urban": A New Way to Measure Metropolitan Areas*, http://dx.doi.org/10.1787/9789264174108-en.

2.2. Indicators as instrument for evidence-based policy-making[5]

Indicators are important tools to create an evidence base from which to build better policies. They provide information that can help to structure the complex and multi-faceted environments in which policies operate. Well-designed indicators are measures that identify trends over time, allow for objective comparisons and highlight areas that need particular attention from policy makers. Thus, indicators can help policy makers to better design the policies that are necessary to improve cities.

[5] This section draws in important parts on inputs from Schumann (2016).

Furthermore, indicators can help to identify which policies are effective in improving resilience. By definition, policies should be outcome-oriented, in the sense that they are designed to achieve their objectives. Yet, it is hard to know in advance what the effects of a policy will be. Ideas that sound good in theory often disappoint in practice, whereas others turn out to be unexpectedly successful. Even policies that have been tested in the past can have different effects than before when seemingly unrelated circumstances have changed in the meantime. Therefore, policies have to be monitored and evaluated to determine what their effects are. Without systematic monitoring and evaluation, it is difficult to separate policies that work well from those that do not.

Indicators play a central role in the monitoring and evaluation process by generating regular and objective feedback on progress towards policy objectives. They are quantitative representations of the conditions in given a policy field. They can be used as a tool to examine the effects of policies and they provide crucial information for policy makers to judge the effectiveness of policies and to make adjustments where required. Compared to many other feedback mechanisms, well-designed indicators have the advantage of providing easily comprehensible information. Thereby, they can form a factual basis upon which informed political decisions can be taken.

Indicators can also facilitate learning beyond the scope of individual policies. By providing regular feedback on the effectiveness of policies, they contribute to better understanding what types of policies are effective and what types do not work well. In the long run, their use can improve the general quality of policies and the overall effectiveness even of those policies that are not monitored by indicators. In other words, outcome-based performance measurement enables policy makers to learn whether a policy initiative or national strategy is working – i.e. whether it is achieving the results it was designed to achieve. This knowledge is crucial because it enables policy makers to change course, if needed.

Beyond their immediate task of informing policy makers, indicators can further contribute to creating transparency and accountability. By representing central outcomes of a policy field in a single number, indicators provide an objective yardstick for the public to judge progress in a given policy area. Still, reducing outcomes to a single number implies that complex situations are simplified. While this can make them easier to grasp, it might also over-simplify and thereby obscure the picture.[6]

Despite the obvious importance of indicators, they are not an end in themselves but rather an instrument to analyse whether policies achieve their desired outcomes. The focus of a policy should always be on the policy objective and never on the indicator itself. Concentrating on improving an indicator instead of achieving the objective runs the risk that policies are tailored to do well on the indicator but perform badly in terms of achieving their broader objective. This risk becomes even greater if financial or other performance incentives are based on indicators. Therefore, when using indicators, it should regularly be scrutinised whether policies are still aligned with their actual objectives. Moreover, these policies should be pursued. Indicators, as measurement techniques, do not replace programmes and projects that will actually contribute to reach a given policy objective.

[6] See OECD (2009) and Van Dooren, Bouckaert and Halligan (2015) for a discussion on the uses of policy indicators.

The role of indicators in the resilience-building process

Indicators that measure the resilience of cities are part of the resilience-building process. Indicators are an assessment, information and monitoring tool. As an assessment tool, they help identify risks and vulnerabilities. As an information tool, they can better instruct the design of early-warning systems, emergency response plans, land-use plans and building codes, as well as raise awareness and communicate about vulnerability and risks. As a monitoring tool, they can identify how well a city has responded and recovered to disasters and shocks and whether the targets have been met. Hence, indicators are present during the whole resilience-building process.

Each indicator refers to a specific element of one dimension of resilience-building. For instance, the indicator of "percentage of households with access to clean water" accounts for one aspect of the health situation of a household, and for one condition of the water and sanitation systems (see Annex 2). This indicator shows, in terms of infrastructure, how much of coverage expansion a city should invest in, with the aim of reducing the health risks of those without access to clean water. In all, other elements also contribute to or hinder the health of a household, and other elements can indicate the quality of a water system. In this sense, each indicator can account for one specific aspect or element of the overall scenario.

To conclude, indicators both inform and are informed by the process of resilience-building. For one, they provide the necessary information on how well-prepared a city is to cope with risk. This information will, in turn, enable a more efficient design and implementation of mitigation, response, and recovery tools and programmes. At the same time they are a fraction of the broader process, that is, they are informed by it. This process involves calculating indicators and setting targets, but also designing and implementing plans, programmes, projects and tools. That is, indicators can instruct better plans and actions, but plans and actions still have to be implemented in order to drive change. In this sense, indicators are not absolute or self-contained; they are a fundamental part of the process of resilience-building in the risk governance process.

2.3. Types of indicators

Indicators in the policy-making process can play two fundamentally different roles: they can inform policy makers about baseline conditions or they can provide information on the implementation of policies and their performance. Baseline indicators provide information on the existing conditions that policy makers have to take into account when formulating policies. While the dimensions measured by baseline indicators affect what policies target, they are not themselves the target of the policies formulated with their help. They may measure dimensions that are not under the control of local policy makers or dimensions that fall into policy domains not related to resilience.

Good examples of baseline indicators are measurements of demographic characteristics, such as the "percentage of elderly population" or the "percentage of population with sensorial, physical or mental disability" (Cutter, Ash and Emrich, 2014). Knowing those numbers is important for policy makers because these population groups have specific needs. When designing evacuation plans, for instance, it is necessary to know how many people have impaired or limited mobility or need to be taken to special shelters. In recovery periods, specific policies should be designed to facilitate the housing reinsertion of elderly in affected neighbourhoods, or to include

those with disabilities in the labour market after an economic shock. The baseline indicators assist policy makers in designing and implementing more effective policies. They do not express any policy objective on their own, though. Reducing the percentage of elderly population in the total of the city's population does not by any means reflect a policy target. It is not the expected outcome of any policy, either.

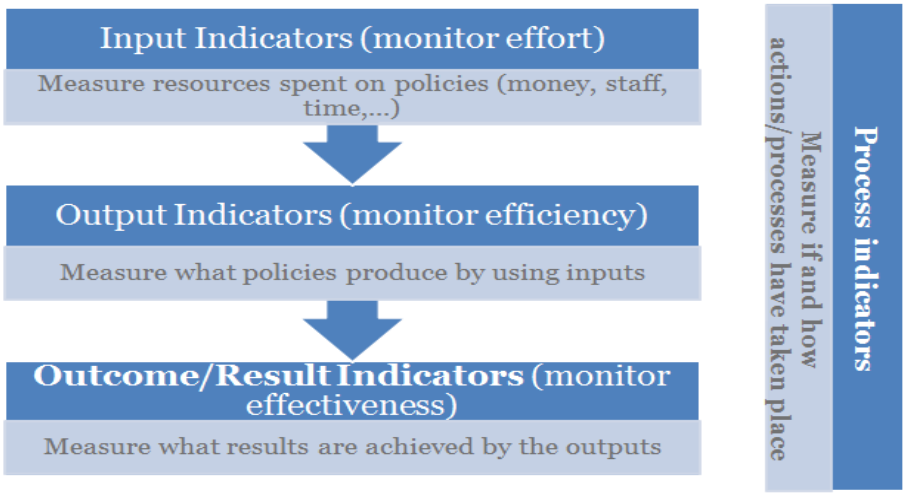
In this sense, the primary role of baseline indicators is to help policy makers obtain a better understanding of the setting they are operating in and the challenges they have to respond to. For example, the expected sea level rise over the next three decades is beyond the control of any single local government, but it is important for many policy decisions, e.g. related to long-term infrastructure investments. Another example of a baseline indicator is the average income level of the local population. In contrast to the previous example, this outcome can be influenced by a local government. However, in many contexts policy makers still need to take it as given. For instance, a policy maker working on local healthcare would probably find this information relevant, but cannot expect to directly affect it through health policies. Thus, this type of indicator provides a baseline to which to tailor policies, but cannot be used to create targets related to the policy.

Policy indicators measure the performance of policies along different dimensions. Contrarily to baseline indicators, they can be used to assess the effort, efficiency and effectiveness with which a policy is pursued as well as the process through which it is pursued. Thus, they provide a picture of the general environment, and also generate direct feedback on policies. As discussed in the following section, different types of policy indicators can be distinguished according to the step in the policy-making process that they monitor. While this distinction may at first appear of little practical relevance, it is crucial that the right type of indicator is used for monitoring a given step.

Different policy indicators measure different aspects of the policy-making process

Policy indicators can be classified into four general categories according to what is measured: input indicators, output indicators, outcome indicators and process indicators (Figure 2).

Figure 2. Four main types of policy indicators



Source: own elaboration

Input indicators are used to measure the amount of resources that are available to a policy. A typical input indicator is the amount of funds spent on a certain policy or the number of people working on a project. While input indicators measure the resources dedicated to a policy, they do not give any information on whether resources are efficiently spent or whether a policy is effective in achieving an objective. Therefore, they should usually be employed in combination with other types of indicators. It is not possible to monitor policies comprehensively using input indicators alone.

Output indicators measure quantities that are produced by a policy in order to achieve its objectives, but not how effective or successful the policy is. Outputs are means to achieve a policy objective, but not an end in them. They are produced because policy makers expect them to contribute to desirable outcomes. Typical output indicators might show the length of a new flood protection barrier, the number of people trained to fulfil a task or the area for which environmental protection plans have been developed. Output indicators do not provide any information on whether the outputs of a policy are effective in achieving the desired outcomes of a policy, i.e. if the outputs do what they are supposed to do. For example, they cannot show whether training was effective or how much participants actually learned from it; rather they can only show that a certain number of people received training. Consequently, the primary purpose of output indicators is to monitor if a policy is efficient in producing outputs, not if those outputs are achieving what they are supposed to achieve.

Another example of output indicator is the "number of physicians per 100 000 people". Policy makers can implement a programme to increase the number of physicians in a given city (output), with the objective of improving health and emergency care to its population (outcome). They will need to invest resources to implement this programme (input). It is expected that a higher proportion of physicians will translate into better services, which would then contribute to the desired policy objective of better quality of healthcare and emergency services.

Outcome indicators are used to monitor the effectiveness of policies in achieving their objectives. They help to understand whether policies are well-designed in view of their objectives. Outcomes are the underlying motivation behind policies, but they can rarely

be directly affected by a policy. Typical outcome indicators related to resilience might refer to the time it takes to evacuate a city in the event of a storm, the innovative potential of a city's economy or the degree of social cohesion within a neighbourhood. All of these outcomes have a point in common: policy makers do not have direct control over them. In order to affect them, policy makers need to implement policies that affect the outcome indirectly, often through the outputs that they produce. For example, no law can decree that a city be evacuated faster. In order to affect this outcome, policies have to be developed, for instance, an evacuation plan (i.e. an output), under the assumption that this could facilitate emergency evacuation. In the context of resilience, many relevant outcomes are highly complex and influenced by a large number of policies and by factors beyond the control of policy makers.

Process indicators refer to actions or processes that have taken place. Typically, they show whether an action occurred or not, without actually demonstrating whether the action has achieved its outcomes. They are useful to obtain a better understanding of complex processes and identify at an early stage if the implementation of a policy is stalling. Furthermore, they may be useful if there are long time-lags between an action and the materialisation of its result.

Process indicators can also emphasise how plans and projects are enacted and implemented. They could help to identify whether the policy-making process is open, inclusive and integrated. As participatory governance gains importance in the policy-making arena, process indicators become more important. Nonetheless, process indicators may struggle to measure qualitative characteristics of processes that are important in determining their success.

There are many benefits to adding process indicators to a resilience framework. Inclusiveness, as a quality of resilient cities, requires that the process of building resilience should involve broad consultation and engagement of different local stakeholders. In addition, integration of policy sectors is another quality of resilient cities, as it helps to bring different perspectives together and incorporate the multi-dimensionality of risk.

Process indicators refer to the institutional dimension of resilience, and to the sub-driver of popular participation and open government. One example of a process indicator is land-use plans developed with reference to a relevant hazard risk assessment and subjected to a formal consultation process (see Annex 2). Land-use plans may include the city master plan, hazard mitigation plan and an emergency response plan. The consultation process must be formal, that is, following written procedures and duly recorded. It should involve a broad range of local stakeholders, including high-risk minority population groups and technical experts. Risk-based, inclusive and participatory urban planning is central to an effective resilience strategy.

Another category of process indicators for institutional resilience refers to vertical and horizontal collaboration across levels of government. Vertical co-operation is needed to ensure funding availability to resilience-building projects, provided that objectives are aligned. The national government is typically responsible for providing adequate (and timely) funding to local governments to respond to disasters. Horizontal co-operation arises from the very basic fact that risks do not respect administrative borders. Air pollution and water contamination are risks that may travel across territories governed by different authorities. Box 6 illustrates how water risks can be felt across different municipalities, even in different countries, and the related co-operation efforts that emerge from this situation.

Box 6. Managing water risks across the US-Mexico border

The Paso del Norte, a region that includes the "sister" cities of El Paso, Texas (United States) and Ciudad Juárez, Chihuahua (Mexico), is faced with a complex set of water supply problems that embody the range of water issues found elsewhere along the US-Mexico border, among them:

- Water is scarce, and competition for water resources is intensifying.
- Per capita water use is higher on the US side of the border than on the Mexican side.
- Agricultural water use is relatively constant; increased water demand is being driven by urban growth.
- Upstream surface water irrigation acts to reduce downstream flow and degrade downstream water quality by concentrating dissolved minerals.
- Intensive human use of water resources has impoverished natural ecosystems.
- The quality of existing water resource infrastructure, financial capability and technical capability is greater on the US side than on the Mexican side.

The severity of water problems in the Paso del Norte has forced greater interaction among the many entities charged with aspects of water management in the region. Some factors favour regional water management planning, among which are: the growing economic interdependence of El Paso and Ciudad Juárez; physically, water resources are shared; drought, when it occurs, will affect all jurisdictions; combining resources can help attract more outside financial assistance; and a growing sense of a shared destiny.

There are several examples of positive co-operation efforts in shared water management in the Paso del Norte region: El Paso Water Utilities (EPWU) is the sole water planning entity for El Paso County; the New Mexico-Texas Water Commission provides a forum for bi-state dispute resolution and led to the development of the Las Cruces-El Paso Sustainable Water Project; and the seven-county Far West Texas Water Planning Group, that incorporated a "bottom-up" approach to state water planning. The Lower Rio Grande Water Users Association, initially created to help counteract El Paso's efforts at gaining access to New Mexico water, is today co-ordinating water planning in Doña Ana County. The Tri-Region Water Planning initiative is exploring the potential of mutually beneficial water supply projects. Voluntary organisations are also active, examples of which are: Aqua XXI, a non-governmental organisation working to promote more dialogue regarding water issues in Ciudad Juárez; the Paso del Norte Water Task Force, that is promoting regional water planning; and the Paso del Norte Watershed Council, focusing on environmental issues along the Rio Grande/Río Bravo.

Despite efforts at promoting regional water planning, numerous factors continue to hamper co-operation, among which are: existing, inflexible water allocation systems; different legal systems; different economic pressures and financial abilities; centralised versus decentralised decision-making structures; cultural differences that influence water use; differences in perspective (long-term future versus immediate needs); and a lack of complete information regarding the region's water resources, particularly in Mexico.

Source: Turner, C., E. Hamlyn and O.I. Hernández (2003), "The challenge of balancing water supply and demand in the Paso del Norte".

In all, the four types of indicators are relevant for monitoring the process of resilience-building in cities. Input, output and outcome indicators can all help to monitor the effectiveness of policies, but it is important that each type of indicator be used to monitor only the aspects of a policy it is designed to monitor. In particular, it is essential to avoid using output indicators to measure outcomes. Therefore, it is important to be aware of the types of indicators and use them according to their purpose.

2.4. Resilience can be measured directly and indirectly

Resilience is the ongoing capacity of cities to resist, adapt, transform and prepare for shocks and stresses, be they of environmental, social, institutional or economic origin, with the aim of maintaining the functions of the city and improving response to future shocks. In most circumstances, this capacity cannot be observed directly. Cities that do not face significant shocks and stresses regularly or that respond adequately to minor shocks may not be perceived as resilient, simply because disruptions to the system could not be observed in the first place. Resilience only becomes apparent during a major shock or stress that requires a city to resist, adapt and transform.

In this sense, resilience as an outcome can only be directly measured in the aftermath of a disruptive event; it is only then that it becomes apparent whether a city can absorb, recover or adapt. Furthermore, resilience to future shocks and stresses is only indirectly observable by using input, output, outcome or process measures that are likely to influence resilience. In this respect, resilience is no different from other outcomes. For example, past GDP growth can be measured accurately, but future GDP growth can only be predicted imperfectly. Consequently, a fundamental difference between direct indicators and indirect indicators of resilience exist. The following section discusses the differences between the two types of indicators and their strengths and weaknesses.

Direct indicators of resilience measure if cities have been resilient in the past

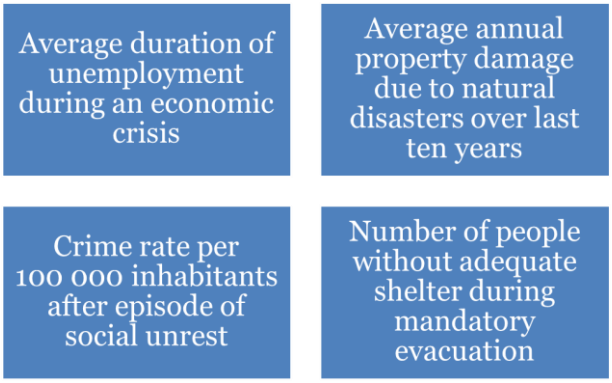
Direct indicators of resilience can describe a city's performance in the face of an actual shock. To the degree that the dimensions of resilience are quantifiable and measurable, direct indicators of resilience can provide an accurate measure of the resilience that a city had against the specific shock it experienced. It is for this reason that they are well-suited to provide an overview of the actual degree of resilience a city has had in the past.

For the actual policy-making process, indicators on resilience have the disadvantage that they show only the response to shocks and stresses that actually occurred, but are less informative about resilience to future potential shocks and stresses. The information which they provide may be specific to a particular event and may become obsolete over time, as conditions change. Thus, the degree to which direct indicators can guide policies depends on whether the factors that influenced resilience in the past will also influence it in the future. The less the conditions have changed since a previous shock, and the more likely it is that a similar shock hits again, the more information direct indicators can provide. This implies that direct indicators are most useful to measure resilience against shocks that occur frequently (for example regular patterns of severe seasonal weather, seasonal patterns of influenza infections, etc.).

In line with the framework above discussed, direct indicators of resilience are always outcome indicators. They measure some of the dimensions that are the objective

behind policies to improve resilience. At the same time, public policy cannot affect them directly. Instead, it has to use inputs (resources) to produce outputs in the expectation that these outputs might affect measures of resilience.

Figure 3. Examples of direct measures of actual resilience

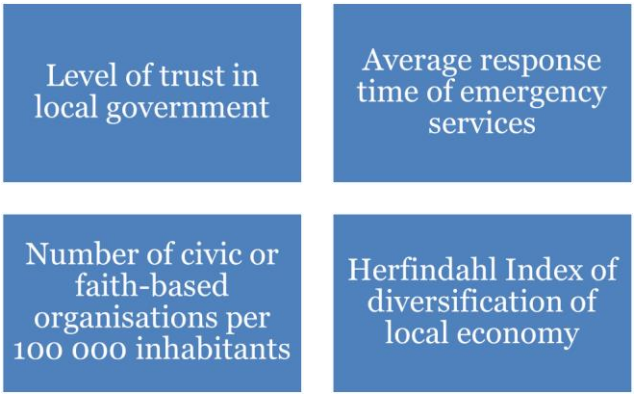


Source: own elaboration.

Indirect indicators of resilience measure if cities are likely to be resilient in the future

Indirect indicators of resilience measure current characteristics of a city that can be expected to influence (positively or negatively) the degree of resilience to future shocks. In other words, they do not measure resilience directly, but measure related inputs, outputs, outcomes and processes that are likely to influence resilience. Their quality as indicators for resilience primarily depends on whether the factors that they measure are actually related to resilience.

Figure 4. Examples of indirect measures of resilience



Source: own elaboration.

As it is the case for all indicators trying to measure future performance, indirect indicators are imperfect predictors of future resilience. While this is the case for all forward-looking indicators, the uncertainties surrounding indicators on resilience are particularly high due to the specific characteristics of resilience. Uncertainty around indicators comes partly from the fact that the consequences of a particular characteristic of a city on resilience are hard to determine. For example, a high civic

participation rate of citizens in community associations and similar organisations is likely to make a city more resilient to the effects of some environmental disasters because it provides structures from which community responses can develop. Yet, besides the general notion that participation in community organisations is beneficial, it is difficult to quantify more precisely the increase in resilience that can be obtained from it.

More importantly, the uncertainty surrounding measures of resilience is higher than the uncertainty surrounding other indicators, because they are related to risks that are often hard to foresee. In other words, it is difficult to know against what shocks and stresses cities need to be resilient. For some shocks (e.g. some natural disasters), it is possible to predict with reasonable certainty how a shock will occur. Furthermore, it may be possible to determine a rough probability with which such a shock will hit a city in a given year. Likewise, many long-term stresses unfold slowly, which could possibly give sufficient time to prepare for them before they reach crisis proportion. However, many other shocks are less predictable in their nature, either because their characteristics are unpredictable or because the probability that they occur is unknown. In some cases, cities may be hit by shocks that have not been considered by policy makers at all. Even in the case of long-term stresses, it is not assured that they are recognised before they become urgent issues.

Identifying suitable direct and indirect indicators of resilience

In light of the uncertainty surrounding shocks and stresses, it is important to identify clearly which factors contribute to resilience. This requires learning about what determines resilience in general and more specifically in the context of the particular city. At least partially, this process must occur before indicators are chosen. Policy makers need a good understanding of what determines resilience in order to develop an effective system of indicators measuring it.

In order to identify past shocks and determine the inputs, outputs, outcomes and process that played a particularly important role during past crises, policy makers can conduct risk assessment studies (see 2.1). Such studies quantify the magnitude and impacts of previous disasters and shocks in the city, as well as account for the probability and consequences of future disaster events. The risk assessment report should be part of the planning process, to help stakeholders understand the underlying and future patterns of risks (Jha, Miner and Stanton-Geddes, 2013: 49). Departing from the risk assessment study, well-informed risk-based land-use plans can be designed, and appropriate indicators can be identified. In order to better understand potential weaknesses, it is important to develop an institutional culture that encourages critical and objective self-assessment.

Proxy indicators are a special case of indirect indicators of resilience

A particular group of indirect indicators are proxy indicators for factors contributing to resilience. These indicators measure factors that are related to resilience, but that do not contribute to strengthening resilience themselves. The share of people knowing the names of their neighbours illustrates the case of proxy indicators. This indicator is not a direct measure of social capital, but it functions as a simplified way to account for it. The underlying assumption is that neighbours who know each other's names would have developed (and continue to maintain) social ties. Interpersonal local ties are an important component of social capital, as they increase the sense of belonging and

social cohesion levels (Tran et al., 2013). Knowing your neighbours' name works as a proxy for social capital, what is an important element of social resilience (Box 7).

Box 7. Why social capital matters in disaster recovery

Putnam defines social capital as "features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated action" (1993: 167). Social capital is the glue that binds communities together. Economies with high levels of social capital are top performers on such social and economic indicators as health, social integration, national wealth, democracy and trust in governmental institutions (Putnam, 2000).

Social capital matters in disaster recovery. Communities with high levels of civic engagement and social ties tend to act in an organised and resolute manner when faced with disaster (Aldrich, 2015: 25). Estimates show that 90% of people are rescued by neighbours (GFDRR, 2017). Information about warnings, food and shelter tend to be provided by social networks (Aldrich and Meyer, 2015). Participation in voluntary associations and local clubs makes people less lonely and contact with others creates trust. People with more ties to the community tend to stay or move back, and this seems to apply across different types of ties, with friends, family or the workplace (Aldrich, 2015). Social capital has nonetheless a "dark side"; it can be used during disaster recovery to keep outsiders excluded and cater the self-interests of the insiders' group (Aldrich and Crook, 2008).

Policies need to focus on programmes that include social capital as a key factor in post-disaster rebuilding efforts locally, nationally and internationally (Aldrich, 2015). One strategy to do so is using pre-existing networks and activities in communities as arenas for debating disaster and resilience topics. A related policy instrument is time banking or community currency to encourage volunteer community work (Richey, 2007). Focus groups and social events are other instruments for increasing social capital, as neighbourhood groups have increased levels of trust and developed disaster preparedness. Establishment of planned physical meeting spaces and places, including third places (e.g. cafes, libraries, community centres), is another type of instrument for social capital generation (Aldrich and Meyer, 2015).

Adapted from: Varheim, A. (2016), "Public libraries, community resilience, and social capital", www.informationr.net/ir/22-1/colis/colis1642.html.
Sources: Aldrich, D.P. (2015), "Social capital in post disaster recovery: Strong networks and communities create a resilient east Asian community"; Aldrich, D.P. and K. Crook (2008), "Strong civil society as a double-edged sword: Siting trailers in post-Katrina New Orleans"; Aldrich, D.P. and M.A. Meyer (2015), "Social capital and community resilience"; GFDRR (2017), "Inclusive community resilience: Empowering communities for resilience", webpage, Global Facility for Disaster Reduction and Recovery, https://www.gfdrr.org/inclusive-community-resilience?page=12; Putnam, R.D. (1993), *Making Democracy Work: Civic Traditions in Modern Italy*; Putnam, R.D. (2000), *Bowling Alone: The Collapse and Revival of American Community*; Richey, S. (2007), "Manufacturing trust: Community currencies and the creation of social capital", http://dx.doi.org/10.1007/s11109-007-9028-7.

Proxy indicators can be used when the task of measuring the actual contributing factor to resilience reveals to be too complicated or far-fetched. For instance, measuring

social capital would require extensive, in-depth research and data collection. Not only would this be very costly and time-consuming, it would also generate fine-grained qualitative data that surpass the purposes of measuring resilience through indicators. To measure the social resilience of a city, adopting an indicator that is easier to generate and calculate can be more efficient.

Proxy indicators can inform about resilience. However, they should be clearly distinguished from indicators that measure characteristics that contribute to resilience. Otherwise, the outcomes measured by proxy indicators might be confused with outcomes that should be targeted by policies aiming at improving resilience.

2.5. Policy objectives guide the development of indicators

How do policies for resilience differ from good urban policies in general? First, resilience runs across a spectrum from a lesser to a greater degree. When launching a dialogue on urban resilience, perhaps the starting point is not to ask: "Is my city resilient?" but rather to ask: "What degree of resilience does this city want to pursue?" The level of resilience could be decided by establishing consensus among citizens as to how much risk the city is willing to take, considering the frequency and impact of shocks.

Second, resilience in cities focuses on the ability to absorb, adapt to, transform from and prepare for shocks and stresses, while good urban policies focus on the outcome of policies. Policy makers should ask the question regarding good urban policies: "What kind of a city does my city want to become as a result of being resilient?", while asking the question: "How does my city enhance the ability to absorb, adapt, transform and prepare for shocks or stresses" for exploring being resilient.

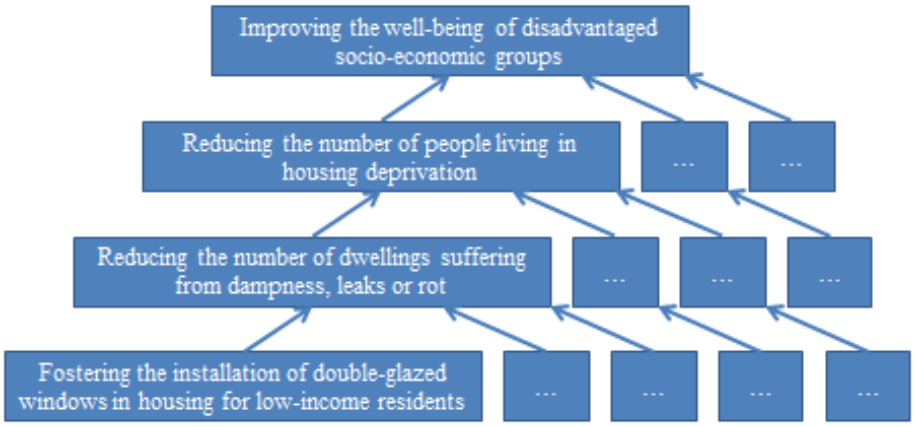
Building resilience in cities requires looking at a city in a systemic manner, since adjustments made in one area are likely to impact other areas. For example, a measure to create a more resilient economy in cities can impact the natural and built environment, as well as the city's institutions and governance. A policy that supports greater innovation capacity and innovative output will require considering the city's skills policy – both part of the economy driver – but can also mean ensuring physical access to opportunities (natural and built environment); developing and supporting amenities to attract human capital (natural and built environment); ensuring that urban development is based on a long-term vision and realised through an integrated approach to planning and implementation (governance). The need for integrated policy approaches is also evident when one driver of resilience is under pressure, as other drivers will also be affected. An urban economy suffering from long-term decline generally experiences higher unemployment, which can impact society, for example in terms of social cohesion, mental health (e.g. increased incidence of depression and anxiety), social isolation and overall well-being.

Policy objectives are needed to identify which dimensions of resilience to monitor with indicators. The decision to measure one dimension but not another implies that more importance is given to the former outcome than to the latter. To some degree, it is possible for experts to provide objective guidance on which outcomes matter most and should therefore be included in an indicators framework. However, at some point the question about which outcomes matter more cannot be decided objectively and involves normative judgements. At this point, policy objectives influenced by political decisions can provide guidance on which dimensions to measure.

Policy objectives have varying degrees of importance. Furthermore, most objectives are not ends in themselves but contribute to achieving higher level objectives. As a result, policy objectives can be ordered in a hierarchical fashion where one objective contributes to achieving one or more objectives at a higher level. For example, the objective of opening kindergartens contributes to improving child care provision, which may contribute to the objective of reducing the unemployment rate of single mothers, which in turn contributes to reducing the share of children living below the poverty line. Arguably, reducing the share of children living below the poverty line is more important than opening kindergartens, but the latter is a means to achieve the former (as well as other objectives). Being aware of the hierarchical order of objectives related to indicators can create a better understanding of how policies interact and facilitate the development of appropriate indicators.

Figure 5 shows a hypothetical hierarchy of policy objectives related to improving resilience through housing policy. Each policy objective at a lower level contributes to achieving a policy objective at a higher level. For example, encouraging private landlords to install modern double-glazed windows may contribute to reducing the number of accommodations suffering from leaks, dampness or rot. In turn, reducing the number of accommodations suffering from leaks, dampness or rot may reduce the share of people living in housing deprivation, which in turn contributes to greater social resilience. This is so because inadequate housing is more susceptible to natural disasters, creates mental and physical health risks, and may ultimately hamper social inclusion.

Figure 5. A hypothetical hierarchy of policy objectives related to resilience and housing



Source: own elaboration.

Importantly, each objective is just one of many possible ways to contribute to a higher level objective. For example, reducing overcrowding could be another objective contributing to reducing housing deprivation. Often, different objectives are complementary in the sense that they are only effective if pursued in parallel. To illustrate, the renovation of dilapidated housing stock might only be effective if not only windows, but also roofs and internal plumbing are restored. In such instances, policy makers should target all measures simultaneously. However, in other instances, different policy objectives have the same effect on higher level objectives and policy makers have to choose the objective that seems to be the most effective. For example,

the quality of the housing stock can be improved by renovating existing stock, but also by demolishing and reconstructing it. In this case, policy makers have to decide which pathway is the most effective and set objectives accordingly.

The idea of structuring policy objectives hierarchically is also reflected in the framework of drivers for resilience (Figure 1, Chapter 1). The overarching objective of strengthening resilience is divided into four lower level objectives of strengthening institutional, economic, social and environmental resilience. In turn, each of these four objectives is supported by more specific, lower level objectives. For example, the objective of having a diversified industrial structure contributes to achieving greater economic resilience. The objective of fostering multilevel governance collaborates to enhancing institutional resilience. Each of those objectives is in turn composed of several policies and projects. That is, there is not one policy that is ultimately responsible for diversifying the industrial structure but several, each one with its specific, lower level objective.

Which indicators or aspects to prioritise

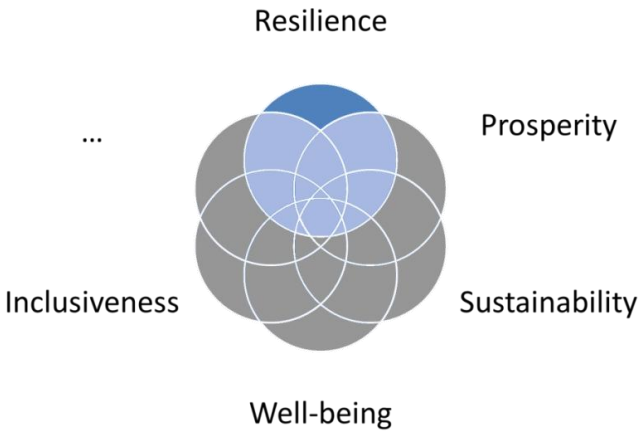
Resilience is a multi-dimensional and complex phenomenon. Due to the large number of factors that conceivably influence resilience, indicator frameworks need to prioritise dimensions that are particularly important for a city; otherwise they risk becoming overly complex and obscure the focus on the most relevant factors. Furthermore, collecting and analysing data for indicators imposes considerable costs on public administrations and potentially the private sector, as already discussed.

Priority should be given to indicators that measure objectives related to policy priorities as well as to those related to objectives where problems have been identified. These are the areas in which indicators have the greatest potential for shaping policy. Furthermore, indicators that can detect early-warning signs for upcoming shocks and stresses are important, especially if it is unlikely that these would be identified otherwise. Information that has been created by indicators can be used to identify dimensions that require particular scrutiny and attention and should therefore be closely monitored by further indicators.

Identifying aspects of resilience that are not yet targeted by public policies

Most policies that foster resilience also contribute to other high-level objectives, such as sustainability, prosperity or inclusiveness. Figure 6 shows stylised sets of factors (e.g. inputs, outputs, outcomes, processes, etc.) that contribute to different high-level objectives. Each circle symbolises the set of factors contributing to a particular high-level objective. Many high-level objectives have overlapping sets of factors in the sense that a factor contributing to one high-level objective also contributes to achieving another high-level objective. For example, ensuring equal access to healthcare contributes to achieving higher well-being, but also increases inclusiveness. Likewise, reducing air pollution increases both social well-being and sustainability. In the figure, such an outcome would fall into the area where the circles for well-being and sustainability overlap. Certain factors might contribute to several high-level objectives. For example, improving schooling is arguably important for inclusiveness, well-being, prosperity and resilience. In Figure 6, this outcome would fall into the area where the corresponding four circles overlap.

Figure 6. Schematic set of objectives for selected high-level policy priorities



Source: own elaboration.

Outcomes that improve the resilience of a city often contribute to other high-level objectives. For example, higher GDP may contribute to resilience because wealthier cities have greater financial resources available during a crisis. Obviously, higher GDP also fosters greater prosperity and well-being in general. Thus, it is unlikely that a policy maker would aim at increasing GDP primarily to improve resilience. Likewise, many OECD cities may not have been aiming at achieving greater resilience in the past, but were striving for greater environmental sustainability. In doing so, many have also improved their resilience. Thus, even cities that were not actively targeting resilience have undertaken important steps to becoming more resilient.

As a consequence, a renewed focus on resilience is often not enough to lead to substantial changes in the policy-making arena. The argument that greater resilience requires, for example, higher levels of GDP or greater levels of environmental sustainability may be insufficient to encourage reforms, simply because these are already objectives pursued by policy makers. Thus, it may be of little practical relevance for them to learn that resilience would improve if the city GDP increases.

In order to encourage change, policy makers should identify factors that foster resilience but that are not targeted or only insufficiently targeted under current policies. For example, most cities are likely to have policies in place to support higher GDP growth and it is difficult to find ways to go beyond these policies. However, some cities may lack policies aiming at a diversified economic structure, which is one of the building blocks of a resilient economy. In such cases, it may be easier to target policies to support diversification than to develop policies to support GDP growth.

Policy fields that are exclusively related to resilience might offer more potential for improvement and could therefore be the focus of concerted efforts to improve resilience. Given that indicators can draw attention to policy areas that have not been the focus of policy makers, they can be used to highlight the importance of policy areas that have not been targeted in the past. Since these policy areas have potentially higher returns in terms of improving resilience, indicator frameworks for resilient cities might target outcomes that are specifically related to them.

Excluding indicators not strictly related to resilience

Beyond deciding which policy areas to include in an indicators framework for resilient cities, it is equally important to decide which policy areas not to include in it. This is especially important in light of the vast literature on resilience that refers to a wide-range of indicators that supposedly measure resilience. As discussed earlier, one reason behind the large number of proposed indicators is the fact that cities differ from each other, and dimensions that are important in one city may not be relevant in another. Furthermore, definitions of resilience vary from each other and emphasise different aspects (Chapter 1). As Meerow and colleagues (2016) conclude, they frequently also lack precision, which makes it more challenging to develop a targeted set of indicators.

Broad conceptualisations of resilience may be less effective from a practical perspective. While they make it possible to align a broad coalition of actors behind the goal of improving resilience, they also risk introducing a degree of arbitrariness in the policy-making process. If the goal of improving resilience can justify almost any policy, the term resilience may be used to promote various causes. However, the resulting ambiguity will lead to a declining focus on the aspects that matter most and that can be highlighted by narrower definitions of resilience.

If a framework for monitoring resilience contains too many indicators, it will suffer from a similar problem. Indicators that are of comparably minor importance obscure the focus on those that matter more. Furthermore, if frameworks contain large numbers of indicators, it may be difficult to understand the bigger picture that they provide. This is especially true for indicator frameworks that are not well-structured hierarchically. Lastly, the administrative costs of collecting data required for indicators always have to be justified by the information gain from the indicators. The more indicators are included in an indicators framework, the more likely it is that the benefits from having more information be outweighed by the burden data collection.

In order to decide which policy indicators to include in an indicator framework for resilience, Figure 6 distinguishes outcomes into three categories. First, there are dimensions that contribute primarily to achieving greater resilience but do not contribute to other high-level objectives. These dimensions are the least likely to be already targeted in cities that did not pursue resilient city policies in the past and could form the core of an indicator framework for resilience. This set of dimensions is shown in dark blue. Second, there are dimensions shown in light blue that contribute to greater resilience and also to other important high-level objectives. These dimensions are often already targeted by existing policies. They can be included in an indicator framework, but should be assessed for their policy relevance. If they are not policy relevant in the sense that they provide an impetus for new or revised policies, they should be included as baseline indicators only. Third, there are dimensions that contribute to other high-level objectives, but not to resilience. Even though many of these outcomes are important, they should not compose an indicators framework on resilience. They are shown in grey in **Figure 6.**

Focusing on objectives and using indicators as tools to achieve them

Indicators are tools that can help to ensure that policies achieve their objectives, but they should not be regarded as objectives themselves. Policies should always prioritise achieving an objective, not on achieving a good indicator reading. Policies that focus on indicators instead of objectives cause two problems. First, they might be ineffective

or even counterproductive in achieving an objective. Second, they can create the false impression that conditions in a policy field are more favourable than they actually are.

Even well-designed indicators are seldom perfectly representative of a policy objective. As a consequence, it is often possible to selectively improve an indicator while contributing little to the actual policy objective. For example, a policy to foster resilience could be to strengthen community approaches to disaster preparedness. A related indicator could be the number of community associations (e.g. local Red Cross groups, etc.) focusing on disaster preparedness. While this indicator would measure an important aspect of community disaster preparedness, it would nevertheless capture only one of many relevant dimensions related to community disaster preparedness. Policies should always focus on the dimensions that are most important to the objective and not necessarily only on those measured by an indicator.

2.6. How to develop a set of indicators

Cities should compose their own set of indicators. It has been widely recognised that a single prescriptive scorecard does not suit cities of different sizes and contexts (City Resilience Index, 2016; UNISDR, 2012). Different contexts are formed by varying disaster risk levels, but also, among other factors, by the demographic characteristics of a city, data collection capacity and institutional structure. For instance, cities that are earthquake-prone need to develop strong and specific risk assessment and related response capacity, whereas cities that are not normally affected by earthquakes would not frame this risk as central in their plans and programmes.

Furthermore, **the goal of resilience strategies should be to track progress in the same city**, not to compare cities against each other. Precisely because of the different contexts, as well as the uncertainty of risks, it is difficult to affirm that a city is "more" or "less" resilient than others. A "ranking" of cities would be of little practical help in assessing preparedness levels and indicating directions for change. A city gains more by comparing its own state over time, i.e. measuring progress in relation to its ability to cope with disasters. In this sense, it is more useful that a city compares itself with its own conditions in the past than with other cities in the present.

Indicators should be set in the beginning of the process of building a resilience strategy, after risk assessment analysis and before policy-making. Indicators should be able to provide information on how resilient a city is in a very detailed manner. They are precisely the measurement technique that enables cities to design plans, programmes and policies in an informed way. That is to say, indicators inform the policy-making process

Beyond locally tailored indicators, certain basic indicators should be included in most sets of indicators. Some factors matter for all cities, such as the poverty rate, employment levels, etc. **These standard measures should be complemented by context-specific, locally tailored measures**. To illustrate, a coastal city would assess rising sea levels, as well as the robustness of flood-proof infrastructures, while the same would not be true for an inland city. Yet, all cities can gain from being aware of the share of households with broadband service or the number of physicians per 100 000 inhabitants. In all, a combination of standard and contextual measurements yields the most complete picture (Winderl, 2014).

Combining direct and indirect indicators; quantitative and qualitative metrics; and input, output, process and outcome indicators is a good intuition. However, given that

each type of indicator has its strengths and limitations, it is important to be precise about what different indicators measure and to use them accordingly. For example, an indicator measuring the amount of resources spent on improving waste collection and treatment can show that the effort to improve has increased (input). It cannot show that environmental resilience in itself has increased (outcome). In particular, outcomes should always be measured by outcome indicators and outputs by output indicators. Although this sounds obvious, output measures may be easily mistaken for outcome indicators. Given the uncertain link between outputs and outcomes, interpreting an output measure as an outcome indicator could be misleading about the effectiveness of a policy.

Context-specific indicators require public participation. Local agencies, non-governmental organisations, high-risk population groups and minorities have significant knowledge and experience to contribute to the policy-making process. These local stakeholders must be involved during the elaboration and review process of plans, programmes, projects and tools as well as in the design and choice of indicators (UNISDR, 2015). Besides benefiting from their knowledge, local governments would gain in terms of legitimacy and effectiveness of the resilience strategy, as a more participatory strategy is more engaging to stakeholders. Local structures should operate regularly and democratically and integrate the dimensions of risk and safety when defining land uses and zoning rules (United Nations, 2017a).7 Budgets, plans and data should be of open access and easily understandable. In all, participatory resilience-building processes are more legitimate and effective.

Quantitative vs. Qualitative metrics

Resilience metrics can be composed in a variety of ways. The framework of indicators can contain quantitative or qualitative data, or a mix of both. There can be a combination of observational data on actual outcomes and data yielded from modelled techniques to predict future trends and events (Winderl, 2014). They can be based on municipal census or other pre-existing datasets, but also on interviews, expert opinion, modelling techniques and popular consultation.

In addition to quantitative information, a wide range of qualitative information exists that should be systematically collected and analysed. Such qualitative information provides context that can help to better understand the mechanisms through which policies work and how they interact with each other. The use of qualitative and contextual information is an essential complement to the use of quantitative indicators.

For qualitative indicators, the literature suggests self-assessment techniques using scales or thresholds (Khazai et al., 2015). Local governments, together with relevant stakeholders, would answer a questionnaire by attributing a certain level, or scale, to each indicator. The scale can range from 1 to 5, from 1 being "not at all" to 5 being "completely" or "excellent". For instance, to the question of enforcing building

[7] See the concept of "community-based disaster risk management", as defined by the expert working group on indicators and terminology relating to disaster risk reduction: "Community-based disaster risk management promotes the involvement of potentially affected communities in disaster risk management at the local level. This includes community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local action for disaster risk reduction" (United Nations, General Assembly, 2017a: 16).

regulations, the responsible agency would say if the level of enforcement is weak or satisfactory. This same question could be asked to private developers and residents, as to their perception of enforcement levels. In this sense, the self-assessment is based on judgments of how a well a given activity is performed.

The self-assessment method brings advantages and disadvantages. On the one hand, it allows local stakeholders to debate and evaluate complex qualitative questions, such as law enforcement and service delivery. On the other hand, it might be challenged as inaccurate and biased. Governments may refrains from reporting their actions in a neutral manner. Moreover, if the assessment intends to involve other relevant stakeholders, such as civil society groups, community leaders or technical experts, one possible problem is choosing the ones who will voice their opinions and ensuring that their participation is representative enough of the broader society.

Box 8. The Disaster Resilience Index: Example of self-assessment tool

The Disaster Resilience Index (DRI), developed by the Earthquakes and Megacities Initiative, is a monitoring and evaluation tool for benchmarking and measuring progress in mainstreaming risk reduction and resilience approaches in a city's development policies. It is a customizable, self-evaluation tool, empowering city stakeholders to assess key dimensions of resilience within the city's functional and operational activities through a fully participatory process.

Through a participatory process, resilience dimensions and goals are selected, and indicators to track progress are established. From there, city stakeholders answer a questionnaire along key resilience dimensions. They do so not by collecting data or inserting numbers, but by stating what the level of attainment in the matter is. To identify the level of attainment, they resort to five pre-defined benchmarks: 1) little or no awareness; 2) awareness of needs; 3) engagement and commitment; 4) policy engagement and solution development; and 5) full integration.

This process brings stakeholders together to understand how resilient the city is and to track progress on the effectiveness of risk-related policies. What comes out of this evaluation may express perceptions, more than actual numbers. Yet this is not necessarily negative, once the shared perception built around the self-assessment technique can function as a strong driver of effective and co-ordinated action.

Source: Khazai, B. et al. (2015), "A guide to measuring urban risk resilience: Principles, tools and practice of urban indicators".

To overcome the bias of self-assessment methods, one may build qualitative indicators around binary answers (i.e. yes/no). To illustrate, instead of asking how much the local planning framework integrates the dimension of resilience, a questionnaire would simply ask whether risk-based land-use plans, emergency plans and hazard-specific plans exist or not. This would make measurement clearer and simpler, but potentially less accurate. It is not particularly useful to know that a plan exists without knowing its quality, i.e. if it duly incorporates the resilience and disaster risk reduction dimensions, if it was built in a participatory manner, if it is up-to-date, among other factors. A

poorly formulated plan may be ineffective or even counterproductive. Hence, a yes/no metrics might be inaccurate – a major drawback to this measurement technique.

Setting targets

Targets are quantitative representations of policy objectives that show the expected results of policies (Jennings and Manlutac, 2015). They can also work as a means of verification, a way to track progress and motivate change. It is recommended that policy makers set targets that refer to how much change is expected in indicators across a given period of time. To illustrate, a target can be to augment the percentage of people who receive training on first-aid emergency response skills by 10% in the following two years. Furthermore, cities can incorporate the targets of the Sendai Framework and of the 2030 Agenda (see Annex 1) in their own frameworks.

Indicators and related targets are not neutral, but they influence the type, scope and strength of disaster reduction activities (Winderl, 2014). As Winderl (2014) argues, "what gets measured gets done". Therefore, the decision to include certain indicators and not others in a framework signals political priorities. Thus, choosing indicators involves not only technical considerations, but also political decisions regarding policy priorities. Therefore, it should be clearly communicated how indicators are used and what consequences a particular performance may have for agents. If stakeholders are rewarded or penalised depending on an indicator, the associated incentives should be carefully examined with respect to whether they can encourage any unintended behaviour or lead to unintended consequences.

In particular, motivated stakeholders shall not take steps that aim to improve the indicator without promoting the actual policy objective. This issue has been highlighted by Goodhart (1975), who argues that when a measure becomes a target, it ceases to be a good measure. In other words, actors take steps to improve an indicator without actually changing the underlying situation that the indicator is supposed to measure. This can be harmful for two reasons. First, indicators may lose accuracy. Second, and more importantly, any actions taken to improve an indicator without focusing on the underlying circumstances can reduce the effectiveness of a given policy or worse, can have counterproductive effects.

On data: collection, analysis and learning

Enhanced data collection is crucial to measure urban resilience, as indicators are metrics. Local authorities should collect more information and more often so. They should also systematise and render accessible the information collected. Investing in data collection is an important step to create the evidence base needed to develop better policies. It also enables cities to better assess their current situation using risk assessment studies. Up-to-date, complete and easy to understand data are fundamental in developing a framework to measure resilience based on indicators. Compared to the amount of funds spent on many public policies, investments in data collection are often small, but can yield large returns in what regards the effectiveness of policies.

Still, while higher data quality is desirable, local authorities should **avoid overburdening**, residents, businesses, civic organisations and local agencies with data collection efforts (Gregorowski, Dorgan and Hutchings, 2017: 9). Whenever possible, without sacrificing the quality of an indicator, existing data sources should be used. For example, data that are routinely collected by statistical agencies or data from administrative registries should be made available for building indicators. If an

indicator requires new data collection, it needs to be weighed whether the gain in information due to the new data justifies the collection costs.

Indicators should be published regularly, to promote transparency. Indicators on resilience can be an important tool to convey key facts to the public and to build the foundation of an informed public debate. When they are well designed, they contain easily comprehensible information about fundamental conditions in a given policy area. This makes them ideally suited for communication purposes. They can be used to focus public attention on issues and to showcase government initiatives. Furthermore, publishing them regularly increases the transparency and accountability of the administration by providing clear yardsticks of what has been achieved.

Indicators can enhance learning and capacity building, in two basic senses. First, the process of choosing the relevant indicators to measure a city's resilience can foster mutual learning. If this process is open and participatory, local stakeholders with different interests and backgrounds can help decide which indicators to adopt. Because indicators reflect policy priorities, choosing indicators is a way to define priorities. If this is done collectively, the process of choosing indicators constitutes a political process that facilitates a mutual understanding of each other's point of view and consensus building.

Second, indicators also provide the opportunity for **learning about the effectiveness of policies.** By generating continuous feedback on important outcomes related to resilience, indicators help to gain a better understanding of how policies work and to build a stock of knowledge about the characteristics of successful policies. Thereby, they contribute not only to improving the policies that they monitor, but can also improve future policies. The lessons learnt from using indicators should be shared across the public administration.

Limitations of indicators should be taken into account. Indicators can provide valuable information about resilience to policy makers, but they only capture a partial image. In particular, dimensions that are difficult to quantify or to measure are less likely to be captured by indicators. For instance, it is possible to measure the employment rate, but it is difficult to quantify the quality of jobs. As dimensions that are difficult to quantify may be equally as important as those that are not, policy makers need to pay continuous attention to qualitative dimensions as well, which are difficult to capture by indicators.

A second limitation of indicators is related to the fact that they cannot distinguish the influence of a policy from the influence of confounding factors. This is especially important for the interpretation of direct measures of resilience. They are influenced by a large number of factors, many of which are at least partly beyond the control of policy makers (such as the severity of shocks and stresses), whereas others are influenced by public policies (such as the public response to them). Since it is hard to completely disentangle the influence of policy from the influence of confounding factors, the effectiveness of a given policy cannot be determined by indicators alone.

For example, diversification of the local economy is an outcome that contributes to economic resilience. But based solely on an indicator showing increased diversification, it is not possible to argue that the public policy has been successful in fostering resilience. It might be that increased diversification has been the consequence of unrelated developments. Likewise, a decrease in diversification might not be a sign

of a failed policy but the result of external factors that outweighed the positive effects of the policy.

In order to understand why an indicator is moving in a certain direction, it is necessary to use other sources of information and put the indicator into a broader context. Otherwise, indicators might be misinterpreted and overly simplistic conclusions may be drawn about the effectiveness of policies. More generally, it is important to consider indicators as one information source among many, as well as to understand their strengths and shortcomings.

Composing indicators for resilient cities

The list below provides some strategic guidance on how to develop city-specific indicators:

- **Follow standards:** Prefer indicators for which internationally recognised methodologies are available (UN, 2017a). This increased synergy with the global agenda for resilient cities will facilitate tracking progress in meeting the Sustainable Development Goals (SDGs).
- **Be consistent:** Maintain the same indicators and the same measurement methodology over time, whenever possible. The full potential of indicators is realised only by analysing how they develop over time. In order to ensure that consecutive readings of an indicator are comparable, changes in the definition of indicators should be avoided whenever possible. If the measurement methodology changes, the metadata should be kept consistent (UN, 2017a). Greater internal comparability allows local stakeholders to track progress over time.
- **Disaggregate data**: Indicators should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographical location, or other characteristics, in accordance with the Principles of Official Statistics of the United Nations (UN, 2017b).
- **Be precise:** Avoid terms without a precise, objective meaning to qualify indicators. Terms such as "adequate", "comprehensive", "effective" or "sustainable" do not express an objective reality of their own but refer to a desired state whose meaning must be complemented by value judgments (Gregorowski, Dorgan and Hutchings, 2017; Peyroux, 2015).
- **Make numbers understandable:** Prefer percentages or proportions over absolute numbers. With appropriate denominators, indicators gain in concreteness. For instance, instead of measuring the total number of physicians in a city, measure the number of physicians per 10 000 inhabitants. Other examples of normalised indicators are "the number of patent applications per inhabitant" (innovative potential), "the share of residents with secondary education" (skilled workforce) and "the share of a power plant in total electricity generation" (risk of power failures). The normalised variable is easier to understand and can be put into context.
- **Use data sources that become available at regular intervals**: Some data are routinely collected by statistical agencies or other public organisations. For such data, regularity is no concern as the data usually become available at least every year. However, other potential data sources are not regularly available. For example, some potential outcomes, such as public trust in local governments, are best measured by surveys. Many surveys are one-off data

collections that were not initially designed to be repeated on a fixed interval. When considering such data sources for an indicator, it should be taken into account whether it is possible to collect the data regularly enough to be useful as an indicator.

- **Indicators should be explained**: Each indicator should be accompanied by background information (**metadata**) that allows an appropriate interpretation of the data. The background information should describe how the input, output, outcome or process that is measured by the indicator contributes to the objective of achieving improved resilience. In order to do so, it should contain a brief description of how the measure is linked to resilience. Furthermore, these metadata should specify the unit of measurement and describe the sample to which the indicator applies. If an indicator is subject to particular caveats or limitations, for example due to the nature of data collection, it should be mentioned, too. Any background information on an indicator should be easily accessible and understandable for users, including non-experts.

In alignment with these remarks, the Annex 2 presents a **list of indicators** to measure the resilience of cities, divided across the 4 dimensions and 14 sub-drivers of the resilience framework (see Figure 1 on Chapter 1). Indeed, this paper intends to be useful to local stakeholders when developing a relevant set of indicators to measure the resilience levels in their city and monitoring the effectiveness of resilience-related policies.

To conclude, stakeholders are encouraged to use the table provided in the Annex 2 as a **point of departure** to develop their own set of indicators. The indicators presented here should not be taken as a universally valid set of indicators. Instead, they should serve as examples of potential indicators to measure important dimensions of resilience. In the end, city authorities may come up with indicators that reflect the ones suggested here, or they may think of other, more specific ways to measure the resilience of their city.

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Annex 1. The global agenda for urban resilience

The process of resilience-building in cities is closely linked to the global urban agenda, as set out in the Sendai Framework for Disaster Risk Reduction 2015-2030, the 2030 Agenda for Sustainable Development, the Paris Agreement on Climate Change and the New Urban Agenda adopted at Habitat III in Quito in 2016. This annex explains how resilience is framed in each of these global agreements, what will enable policy makers to foster linkages that can and should be replicated in their local plans.

These global agreements commit to the goals of reducing poverty and inequality, promoting sustainable development, mitigating climate change and supporting human well-being. In that, they sustain that cities should become safer, more inclusive, sustainable and resilient. **Cities acquire a central role in promoting sustainable development**, in which disaster risk reduction, climate change mitigation and resilience are central. In this sense, one of the fundamental ways by which local stakeholders can express commitment with the implementation of this global urban agenda is by **setting resilience as a policy goal**. Plans and programmes across all policy-making sectors should be envisioned as tools to enhance the resilience of cities.

The 2030 Agenda's **Sustainable Development Goals (SDGs)** and resilience are closely linked. The SDGs address, in an integrated manner, the social, economic and environmental dimensions of development and aspects related to peaceful societies and effective institutions, as well as means of implementation, such as finance, technology and capacity development, among others. It has been stated at recent international meetings that sustainable development and disaster risk reduction are "two sides of the same coin", and that climate change adaptation strategies must consider the dimensions of disaster preparedness, mitigation and recovery (Mordt, 2017; Fowler, 2017).

The UN Office for Disaster Risk Reduction (UNISDR, 2015b) identified several direct references to disaster risk reduction and resilience in the 17 SDGs and 169 targets of the 2030 Agenda. References can be found in the goals related to: ending poverty, ending hunger, ensuring healthy lives, education, sustainable management of water, building resilient infrastructure, resilient cities, climate change, and marine and terrestrial ecosystems (UNISDR, 2015b). Across these goals, 23 targets are directly linked to DRR and resilience. **Box** below presents a sample of relevant goals and targets.[8]

[8] The list is an abridged and paraphrased version of the targets. The full text of the targets can be accessed at: https://unstats.un.org/sdgs/indicators/indicators-list. For a complete analysis of how the goals and selected 23 targets relate to DRR and resilience, refer to UNISDR (2015b).

Box A1.1 Resilience in key Sustainable Development Goals and Targets

Goal 1. End poverty in all its forms everywhere

Target 1.5: *Build the resilience of the poor to reduce their exposure and vulnerability to climate-related extreme events, and other economic, social and environmental shocks and disasters*. This target strengthens the position of disaster risk reduction as a core development strategy for ending extreme poverty. The consequences of disasters undermine hard-earned development gains in both developing and developed countries and worsen the situation especially of the poor and most vulnerable. The promotion and development of social safety nets linked with livelihood enhancement programmes would ensure the resilience of vulnerable households and communities to disasters.

Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

Target 2.4: *Ensure sustainable food production systems and implement resilient agricultural practices.* Natural hazards are a cause of global food insecurity and hunger, particularly when they compound existing economic vulnerability. The high impact of disaster and climate risk on agriculture calls for enhanced mainstreaming of disaster risk reduction and climate change adaptation strategies within the agriculture sector. Relevant actions include strengthening productive assets such as livestock, working animals, tools and seeds.

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Target 3.d: *Strengthen early warning and risk reduction of national and global health risks*. People's health and well-being are often affected as a result of disasters and other emergencies. Moreover, damages to health facilities not only cost lives, but also disrupt health systems, facilities and services. Promoting resilient health systems can significantly contribute to building the capacities and resilience of communities to cope with and recover from the impacts of disasters.

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Knowledge and awareness of natural hazards has the potential to influence behavioural change on how people can best protect their lives, properties and livelihoods, thereby contributing to disaster resilience. Target actions 4.7 and 4.a, focusing on building and upgrading education facilities and promoting education for sustainable development, contribute significantly to resilience-building in the education sector. In order to progress these target actions, implementation needs to consider promoting disaster risk knowledge at all levels including in professional education and training, as recommended by the Sendai Framework. Campaigns, social media and community mobilization can be instrumental in promoting and strengthening public education and awareness in risk reduction.

Goal 6: Ensure availability and sustainable management of water and sanitation for all

Water-related disasters such as floods, droughts, hurricanes, storm surges and

landslides account for approximately 90% of disaster events worldwide. Robust and sustainable management of water resources can significantly contribute to reducing the impacts of water-related hazards and strengthen efforts to mainstream disaster risk reduction strategies into water management (Target 6.5). Target 6.6, which relates to protecting and restoring water-related ecosystems, can significantly contribute to strengthening the resilience of communities to water-related hazards.

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation

Target 9.1: *Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.* Infrastructure, such as road, power, communications and water networks, and health and primary education facilities, is a basic requirement of a competitive economy. When infrastructure fails during a disaster event, it can interrupt vital services and threatens the sustainability of businesses. Infrastructure systems that can anticipate, absorb, adapt to and/or rapidly recover from a disruptive hazardous event are considered resilient. Recommended measures are flood control systems, protective embankments, seawall rehabilitation, building codes, retrofitting of buildings, risk-sensitive planning, hazard mapping and disaster risk financing.

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Action targets under this goal (11.1, 11.3, 11.4, 11.5, 11.b and 11.c) aim at upgrading urban slums, integrated urban planning, reducing social and economic impacts of disaster risk, building the resilience of the urban poor, adopting and implementing urban policies in line with the Sendai Framework and building sustainable and resilient urban infrastructure. Measures to achieve these targets and goals require mainstreaming of disaster risk assessments into land-use policy development and implementation, including urban planning, land degradation assessments, and informal and non-permanent housing, and the use of guidelines and follow-up tools informed by anticipated demographic and environmental changes. Local authorities also need to be empowered through regulatory and financial means to work and co-ordinate with civil society, communities and indigenous peoples and migrants in disaster risk management at the local level.

Goal 13: Take urgent action to combat climate change and its impacts

Climate change increases disaster risk and the costs of disasters. Through changing temperatures, precipitation and sea levels, amongst other factors, global climate change is modifying hazard levels and exacerbating disaster risks in different sectors. Investing in disaster risk reduction is a precondition for developing sustainably in a changing climate. Target actions, focusing on *strengthening resilience and adaptive capacity, capacity building and integrating climate change measures into policies and plans, awareness raising on climate adaptation and early warning* (Targets 13.1-13.3 and 13.a and 13.b), provide opportunities to strengthen the integration between disaster and climate resilience. Recommended measures are to strengthen disaster risk modelling,

assessment, mapping, monitoring and multi-hazard early-warning systems; conduct comprehensive surveys on multi-hazard disaster risks; develop regional disaster risk assessments and maps, including climate change scenarios; and strengthen *in situ* and remotely sensed earth and climate observation.

Source : UNISDR (2015b), "Disaster risk reduction and resilience in the 2030 Agenda for Sustainable Development", www.unisdr.org/files/46052_disasterriskreductioninthe2030agend.pdf

Goal 11, known as the "urban SDG", lies at the heart of the resilient cities framework. The commitments to sustainable urban development resonated in the Habitat III context and proceedings. Indeed, the **New Urban Agenda** (NUA) embodies the commitment to sustainable urban development and in so doing it stresses the importance of building urban resilience. [9] It is particularly committed to achieving Goal 11, as it states:

> This New Urban Agenda reaffirms our global commitment to sustainable urban development as a critical step for realizing sustainable development in an integrated and coordinated manner at global, regional, national, sub-national, and local levels, with the participation of all relevant actors. The implementation of the New Urban Agenda contributes to the implementation and localization of the 2030 Agenda for Sustainable Development in an integrated manner, and to the achievement of the Sustainable Development Goals (SDGs) and targets, including SDG 11 of making cities and human settlements inclusive, safe, resilient, and sustainable.

The importance of building resilient cities is reflected across different sections of the NUA. Resilience-building goes hand-in-hand with the promotion of environmental sustainability, which is one of the three core principles of the NUA (14, c). Resilience-building is also one of the main directions in which cities and human settlements should transform.[10] The Implementation Plan for the NUA confirms this commitment, in asserting:

[9] UN-Habitat (2016b) elaborated a guide to assist national and local governments in monitoring and reporting on Goal 11. According to the agency, the Monitoring Framework proposes an "innovative mechanism to avoid an excessive sectoral approach to development", as "implementing isolated targets without a comprehensive approach to the city may undermine the very basic principle of sustainability."

[10] *In verbis*: "we envisage cities and human settlements that… 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" (paragraph 13, g).

> We commit to strengthen the resilience of cities and human settlements, including through the development of quality infrastructure and spatial planning by adopting and implementing integrated, age- and gender-responsive policies and plans and ecosystem-based approaches in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, mainstreaming holistic and data-informed disaster risk reduction and management at all levels, reducing vulnerabilities and risk, especially in risk-prone areas of formal and informal settlements (…). We will promote the development of infrastructure that is resilient, resource-efficient, and which will reduce the risks and the impact of disasters, including the rehabilitation and upgrading of slums and informal settlements. We will also promote measures for strengthening and retrofitting of all the risky housing stock including in slums and informal settlements to make it resilient against disasters in coordination with local authorities and stakeholders.

Resilience and DRR are also closely inter-related agendas. The **Sendai Framework for Disaster Risk Reduction 2015-2030** aims at the substantial reduction of disaster risk and losses in lives, livelihoods and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. As much as it recognises the central role of national governments in disaster risk reduction, it also affirms that responsibility should be shared among stakeholders, including local governments and the private sector.

The Sendai Framework contains seven global targets and four priorities for action. The seven targets reflect the need to reduce disaster loss, in terms of human lives, gross domestic product (GDP) and damage to critical infrastructure, as well as the consequent actions of developing DRR strategies, enhancing international co-operation and increasing access to multi-risk early-warning systems and disaster risk information. The four priorities for action correspond to: understanding disaster risk; strengthening disaster risk governance; investing in DRR for resilience; and enhancing disaster preparedness and efforts to build back better in recovery, rehabilitation and reconstruction. The **priority of investing in DRR for resilience** instructs that it is cost-effective and instrumental for governments to invest in the prevention and reduction of disasters through measures that enhance the economic, institutional, social, health and cultural conditions of communities and people (UNISDR, 2015b). In this sense, investing in DRR fosters the resilience of cities.

The **Paris Agreement on Climate Change** is the first-ever global climate agreement aimed at preventing dangerous climate change and limiting global warming below 2°C. It was adopted during the 21st Conference of the Parties of the United Nations Framework Convention on Climate Change in 2015. Even though mitigation of greenhouse gas emissions is the main focus of the agreement, adaptation to climate change features as a formal global goal as well (Peters et al., 2016: 22). One of the important ways to enhance adaptive capacity is by building resilience in communities, societies and socio-ecological systems. Resilient societies are less vulnerable to the adverse effects of climate change, are better equipped to resist to structural shocks, and can develop innovative and flexible solutions to the challenges brought by climate change.

To conclude, resilience features strongly in the global urban agenda. However, these agreements consider the notion of resilience in different ways, and its incorporation

into goals, targets and indicators also varies (Peters et al., 2016: 46). Resilience could be promoted in a more comprehensive way if there was coherence across the global frameworks, which is yet to be built. Such coherence could contribute to more effective design of strategies, as concerted and integrated strategies are more effective than isolated ones (Peters et al., 2016: 46). Instead of investing time and resources in achieving the goals and targets of these four agreements separately, national and subnational authorities should seek to develop an **integrated implementation strategy** that cuts across the four agreements, using resilience as the link.

Annex 2. Suggested Indicators to Measure Urban Resilience

Aspect	Dimension	Indicator	Type	Justification	Capacities
SOCIAL	Income and inequality "Social inclusion"	Equalised disposable household income (OECD stat)	Outcome Quantitative	Poorer households are more vulnerable to risks. Extensive research over the past 30 years shows that the poor suffer worst from disasters.[1]	Resourceful Inclusive
		Poverty rate (OECD stat)	Outcome Quantitative		
		GINI Index (OECD stat)	Outcome Quantitative	Social inequality translates into unequal access to services and opportunities. Furthermore, it may contribute to socially segregated urban development, which in turn generates new patterns of risk.[2]	
		Spatial segregation (Dissimilarity Index, or Spatial Ordinal Entropy Index at a 1 000-metre scale) (OECD stat)	Outcome Quantitative	Spatial segregation has pervasive effects on the income, education and employment perspectives of poor, segregated groups – as found by the neighbourhood effects literature. It further engenders social divides and lack of trust.	
		Number of homeless people per 100 000 population (ISO 37120)	Outcome Quantitative	Homelessness is a risk, in terms of health, education, employment, family structure, safety.	
		Percentage of jobs paying the city/national living wage (adapted from Arup, 2015)	Outcome Quantitative	Living wages ensure the welfare of workers. The indicator shows whether employment provides a path out of poverty.	
	Social capital and social cohesion "Citizens' networks in communities are active"	Number of civic, social advocacy or faith-based organisations per 10 000 people (adapted from Cutter, Ash and Emrich, 2014)	Output Quantitative	Organisational ties promote a sense of belonging, social mobilisation and engagement, and also enhance interpersonal ties (Tran et al., 2013)	Robust Resourceful Inclusive
		Percentage of neighbourhoods with regular neighbourhood association meetings	Output Quantitative	Neighborhood groups increase sense of place and mobilisation levels at the very local scale, as well as local interpersonal ties (Tran et al., 2013)	

Aspect	Dimension	Indicator	Type	Justification	Capacities
SOCIAL		Perceived social network support (percentage people that replied "yes" to the question: If you were in trouble, do you have family and friends you can count on to help in case of need? (OECD stat)	Outcome Quantitative	Social ties matter for higher quality of life, place attachment and higher likelihood to obtain help and support.	
		Perceived interpersonal local network support: % of people that replied "yes" to the question: If you were in trouble, do you have neighbours you can count on to help you whenever you need them? (adapted from OECD stat)	Outcome Quantitative	Local interpersonal ties increase sense of belonging, social cohesion and support at the neighbourhood or community level (Klinenberg, 1999). Estimates show that 90% of people are rescued by neighbours (GFDRR, 2017).	
	Health and well-being "Citizens enjoy healthy lives"	Percentage of population that has health insurance coverage, including both public and private or have access to "free" (at the point of delivery) healthcare (adapted from the University of Buffalo)	Output Quantitative	Access to healthcare.	Robust
		Self-perception of health % population > 15 years who report "good" or better health to the question "How is your health in general?" with response scale "It is very good/good/fair/bad/very bad" (WHO)	Outcome Quantitative	Overall health state of population. People in worse health are more susceptible to all kinds of shocks and stresses.	
		Average quality of life (satisfaction) (OECD stat)	Outcome Quantitative	Quality of life promotes well-being and is likely to foster aspects such as community cohesion.	
	Medical capacity "People have access to services"	Number of physicians per 100 000 people (ISO 37120)	Output Quantitative	Emergency health needs and overall health service quality.	Robust
		Number of hospital beds per 100 000 people (ISO 37120)	Output Quantitative		Resourceful Flexible
		Percentage of hospitals that have carried out disaster preparedness drills in the last year (adapted from UNISDR, 2008)	Process Quantitative		
	Emergency response services	Average response time of fire response from initial call (ISO 37120)	Outcome Quantitative	Emergency response.	Resourceful Flexible

Aspect	Dimension	Indicator	Type	Justification	Capacities
	"People have access to services"	Average emergency (police) callout response time last year (Arup, 2015)	Outcome Quantitative		
		Perceptions of local government emergency support (Oxfam)	Outcome Qualitative	Perceived level of response to disaster.	
	Communication "People have access to services"	Number of telephone connections (landlines and cell phones) per 100 000 population (ISO 37120)	Output Quantitative	While some disasters may disrupt telephone and Internet networks (e.g. tropical storms and earthquakes), for many other disasters these systems are not affected and in fact prove to be extremely useful (e.g. heat waves, terror attacks, health epidemics). Broadband networks can also be indicative of economic resilience: notably, high-speed broadband networks are associated with greater levels of economic development in cities (Mölleryd, 2015).	Robust Redundant Inclusive
		Percentage of households with access to broadband Internet service (Cutter, Ash and Emrich, 2014)	Output Quantitative		
		Percentage of population with language competency (or proficiency) (Cutter, Ash and Emrich, 2014)	Outcome Quantitative	Communication capacity, relevant in context of recent and significant migratory flux.	
ECONOMIC	Economic diversity "Industries are diverse to generate growth"	Single-sector economic dependence (%, especially primary sector) (Herfindahl Index adapted to sectoral concentration)	Outcome Quantitative	Single sector-dependence increases risk of economic shocks; the primary sector is particularly prone to cyclical fluctuations.	Resourceful
		Reliance on individual firms (Herfindahl Index of firm concentration)	Outcome Quantitative	Firm dependence increases risk of economic shocks	
	Economic innovation "Innovation takes place to the lead economy"	Number of new businesses registered within the city in the past year, per 100 000 population (Case Western Reserve University)	Outcome Quantitative	An environment which supports local business development and innovation provides greater livelihood opportunities for its population and is less reliant on external economic influence.	Resourceful Inclusive Flexible
		Patent applications per million inhabitants (patent intensity, OECD stat)	Outcome, Quantitative		

Aspect	Dimension	Indicator	Type	Justification	Capacities
		Share of tertiary education across the labour force (OECD stat)	Outcome Quantitative	The proportion of the labour force with a tertiary education is a common proxy for measuring a region's capacity to generate innovation (OECD, 2013a), and hence is associated with higher levels of economic stability in the long term.	
	Skills and employment "The workforce has diverse skills"	City's unemployment rate (percentage of working-age population) (OECD stat – Better Life Index)	Outcome Quantitative	Unemployment.	Resourceful
		Percentage of secondary education completion rate (adapted from ISO) or educational attainment (OECD stat)	Outcome Quantitative	Skills help citizens adapt to changes and cope in shock situations. Education positively impacts: communication, alert and awareness, health, labour and employment. Education fosters a greater range and quality of livelihood opportunities.	
		Percentage of people unemployed for more than six months who have access to a programme that is intended to improve their employment chances (European Union, 2015, as quoted in CRI, 2016)	Outcome Quantitative	"Helping city residents develop relevant skills and employability through matching skills with employment needs promotes placement, retention and promotion. It supports the city's economic stability by building a competitive and quality workforce" (City Resilience Index, 2016).	
ENVIRONMENT (natural and built)	Housing "Infrastructure is adequate and reliable"	Housing deprivation: percentage of population living in dwelling considered overcrowded, while: 1) leaking roof or damp walls, floors, foundations or rot in window frames and floor; 2) no bath or shower; or 3) too dark (Eurostat)	Outcome Quantitative	Housing quality. Poor and overcrowded housing is more susceptible to natural disasters, creates social exclusion, and creates mental and physical health risks.	Inclusive Robust
		Percentage of household income spent on housing by the poorest 20% of the population (University of Buffalo) (City Resilience Index, 2016)	Outcome Quantitative	Housing affordability. Adequacy includes access dimension. A higher value implies that the poorest are more at risk of losing access to housing in case of negative income shocks.	
		Percentage of houses which have passed local building code inspections	Outcome Quantitative	Compliance with housing safety standards designed and enforced at the local level indicates higher resilience to disasters and risks faced at the local context.	

Aspect	Dimension	Indicator	Type	Justification	Capacities
ENVIRONMENT (natural and built)		Percentage of housing units exposed to a high level of hazard that have been designed or retrofitted to withstand the force of the hazard	Outcome Quantitative	Retrofitting or designing houses that can properly withstand the expected level of hazard exposure is a prevention measure that makes infrastructure more robust.	Robust
	Temporary accommodation needs "Infrastructure is adequate and reliable"	Percentage of population that could be served by city's access to stock of emergency shelter for 72 hours (Arup, 2015)	Outcome Quantitative	Emergency sheltering capacity, comprising safe schools and hospitals, vacant housing units for rent and hotel/motel rooms.	Inclusive Flexible Robust
		Safe hazard shelter vs. expected public demand (Arup, 2015)	Output Quantitative	Expected sheltering needs.	
		Percentage per capita of food reserves within a city (including supermarket agreements) for 72 hours (percentage of the population which could be served) (UNISDR, 2014, as quoted in CRI, 2016)	Output Quantitative	Emergency food capacity.	
	Energy[3] "Infrastructure is adequate and reliable"	Average number of electrical interruptions per customer per year (ISO 37120)	Outcome Quantitative	Reliability of energy supply to daily needs, without frequent outages.	Robust Flexible
		Number of different supply sources providing at least 5% of electricity generation capacity (World Bank)	Output Quantitative	If a city receives its energy from a diverse range of sources, disruption to overall city supply will be less severe (City Resilience Index, 2016).	
		Number of days that city fuel supplies could maintain essential household functions (UNISDR, 2014, as quoted in CRI, 2016)	Outcome Quantitative	Spare energy capacity for emergencies, even if through alternative sources	
	Water "Infrastructure is adequate and reliable"	Proportion of population using safely managed drinking water services (SDG Indicator 6.1.1) (UN, 2017b)	Outcome Quantitative	Health and contamination risks, environmental quality.	Inclusive Robust Flexible
		Number of different supply sources providing at least 5% of water supply capacity (World Bank adapted from electricity)	Output Quantitative	Diversity of supply sources reduces impact of disruption in services and diminishes drought risk (Buurman, 2016).	
		Percentage of population with access to improved sanitation coverage (ISO 37120)	Output Quantitative	Health and contamination risks. Environmental quality.	

Aspect	Dimension	Indicator	Type	Justification	Capacities
		Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated (SDG Indicator 11.6.1) (UN, 2017b)	Output Quantitative	Health and contamination risks. Environmental quality.	
	Ecology Sustainable urban development "Adequate natural resources are available"	Estimated average exposure to air pollution (OECD stat) or PM_{10} concentration (ug/m^3) (ISO 37120)	Outcome Quantitative	Air pollution creates health risks. Environmental quality.	Robust
		Percentage of wetland loss	Output Quantitative	Wetlands function as flood buffers. Flooding is the most frequent among all natural disasters, and its impacts in cities are especially harsh (Jha, Bloch and Lamond, 2012).	
		Green area (hectares) per 100 000 population (ISO 37120) or average percentage of pervious surfaces	Outcome Quantitative	Permeable surfaces reduce the risk of floods, which destroy buildings and infrastructure. Green areas increase quality of life and well-being (sports, leisure and stress relief).	
	Access and transport "Infrastructure is adequate and reliable"	Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities (SDG Indicator 11.2.1) (UN, 2017b)	Outcome Quantitative	Mobility facilitates access to health, employment, education. It also facilitates access to leisure and engagement in civic activities, which may foster social capital.	Redundant Flexible Inclusive Integrated
		Percentage of households with at least one vehicle (Cutter, Ash and Emrich, 2014)	Outcome Quantitative	Evacuation capacity and increased individual mobility.	
		Number of arterial roads (km/km^2) (Cutter, Ash and Emrich, 2014)	Output Quantitative	Evacuation potential.	
		Death rated due to traffic road injuries (SDG Indicator 3.6.1) (UN, 2017b)	Outcome Quantitative	Road safety.	
INSTITUTIONAL	Risk-based planning "Government ensures citizens' participation and has a clear long-term vision"	Risk assessment report	Process Qualitative	Evaluation needs (disaster risk calculation), prior to any resilience-specific policy design. A risk assessment report is a technical document of disaster risk calculation that identifies the different disaster risks the city is subjected to and the levels of vulnerability of the population (Jha, Miner and Stanton-Geddes, 2013).	Reflective Robust Integrated

Aspect	Dimension	Indicator	Type	Justification	Capacities
INSTITUTIONAL	City leadership that has sufficient capacity and flexibility to effectively manage emergencies.	Land-use plans that have been developed with reference to local hazard risk assessment and that have been subjected to a formal consultation process (Arup, 2015)	Process Qualitative	Risk-based, inclusive and participatory urban planning is central to an effective resilience-building strategy. - Land-use plans include: master plan, hazard mitigation plan and emergency response plan. - Formal consultation process involves high-risk minority population groups and technical experts.	
		Hazard-mapping efforts, including energy facilities and industrial uses	Process Qualitative	Evaluation needs (territorial dimension). Maps inform which territories are more affected by which type of risk, combined with demographic data. City leaders can thus better understand which the most vulnerable population groups are and what territories are particularly fragile, and plan accordingly (World Bank, 2013).	
	Awareness and alert "Citizens' networks in communities are active"	Multi-hazard early-warning system	Process Qualitative	Cost-effective measure to improve efficiency and consistency of warnings, thus improving emergency response to disasters (Jha, Miner and Stanton-Geddes, 2013).	Reflective Robust Resourceful
		Percentage of population that has received training on first-aid and emergency response skills in past two years	Process Quantitative	Training increases awareness and preparedness. It can be extensively carried out in schools, hospitals and the workplace.	
		Percentage of school children educated in disaster risk reduction (UNISDR, 2008)	Process Qualitative	Training increases awareness and preparedness.	
		Capacity-development platforms (online portal, brochures, guides, toolkits)	Process Qualitative	Information increases awareness.	
		Percentage of neighbourhoods with emergency groups (e.g. local Red Cross groups, voluntary firefighting associations, etc.) (adapted from USAID)	Process Quantitative	Local emergency groups organise residents and volunteers to prepare for and react to shocks and disasters. They contribute to higher local mobilisation and civic engagement. They have greater communication capacity among residents, which further contributes to raising awareness and preparedness levels.	
		Level of trust in government	Outcome Qualitative	Legitimacy and effectiveness of public decisions/messages.	
	Transparency and accountability "Government is open"	City open data portal, including budget, organisational structure, plans and projects of different policy sectors	Process Qualitative	Data access is a measure of the openness of government and increases accountability. Open data portals facilitate the development of community-based solutions to challenges.	Inclusive Reflective
		Percentage of access to Information requests processed within 90 days	Process Quantitative	Information access is a measure of the openness of the government and can foster civic engagement, trust and participation.	

Aspect	Dimension	Indicator	Type	Justification	Capacities
	"Collaboration with other levels of government takes place"	The country has mechanisms to ensure co-ordination across levels of government (OECD, 2017b)	Process Quantitative	"Effective collaboration with actors at all levels of government is critical to develop integrated, co-ordinated strategies that make best use of the resources available" (City Resilience Index, 2016).	Integrated
		The country has formal horizontal mechanisms/incentives between subnational governments (OECD, 2017b)	Process Quantitative		Resourceful
	Funding availability "The public sector has proper resources"	Percentage of buildings with insurance cover for high-risk hazards relevant to the city (UN-Habitat)	Outcome Quantitative	Insurance against disasters.	Resourceful
		Ten-year average per capita budget for mitigation projects (Cutter, Ash and Emrich, 2014)	Input Quantitative	Investment in mitigation.	
		Percentage of municipal budget spent in fire, police and emergency services (Cutter, Ash and Emrich, 2014)	Input Quantitative	Level of investment in emergency response.	
		Proportion of total government spending on essential services (education, health and social protection) (SDG Indicator 1.2.1) (UN, 2017b)	Input Quantitative	Level of investment in essential services that can provide education, health and social protection to residents, to fight the risks of poor health, homelessness, inadequate housing, unemployment, poverty and social isolation.	

Notes: Capacities column as set in the City Resilience Index Reference Guide (2016), developed by Arup and Rockefeller Foundation.
1. Information retrieved from: www.preventionweb.net/risk/poverty-inequality.
2. Information retrieved from: www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/GAR15_Pocket_EN.pdf.
3. For a more complete metrics for energy resilience, see Roege et al. (2014).
Sources: Arup (2015); Buurman, J. (2016); City Resilience Index (2016); Cutter, S.L., K.D. Ash and C.T. Emrich (2014); GFDRR (2017; ISO 37120, 2014; Jha, A.K., R. Bloch and J. Lamond (2012); Jha, A.K., T.W. Miner and Z. Stanton-Geddes (eds.) (2013); Klinenberg, E. (1999); Mölleryd, B. (2015); OECD (2013); OECD (2017); Roege, P.E. et al. (2014); Tran, V.C. et al. (2013); UNISDR (2008) ;United Nations, Economic and Social Council, Statistical Commission (2017b); World Bank (2013).