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Policy paper 8: Urban ecology and resilience*

Note by the secretariat

The secretariat of the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) hereby transmits a policy paper entitled "Urban ecology and resilience", prepared by the members of Policy Unit 1.

Habitat III policy units are co-led by two international organizations and composed of a maximum of 20 experts each, bringing together individual experts from a variety of fields, including academia, government, civil society and other regional and international bodies.

The composition of Policy Unit 1 and its policy paper framework can be consulted at www.habitat3.org.

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Policy paper 8: Urban ecology and resilience

Executive summary

As the global population becomes increasingly urban, the design, planning and management of cities become more important to human health, well-being, and quality of life. Inevitably, urban ecology, urban environmental sustainability, and resilience are central to this shift.

This paper argues that we should work towards a future that is environmentally sustainable, with ecologically healthy, low-carbon, resource-efficient, and resilient cities that have the ability to mitigate and adapt to a variety of shocks and stresses. The policy recommendations and implementation proposals outlined in this paper advocate for a participatory and inclusive urban planning and design process that will help make this vision a reality. Incorporating environmental challenges into decision-making is a way to improve quality of life of citizens and increase cities' competitiveness.

Challenges

In the development of this policy paper, two key challenges related to urban ecology and resilience were prominent in discussions of the experts and co-leads. First is the need to change the way we think of cities. The city is primarily perceived as a significant source of negative ecological impacts. But we need to harness the amazing potential that cities have to spark and spur new technologies, practices and approaches that help achieve local and global environmental goals. Cities are hubs of innovation and their density of population provides economies of scale to reduce environmental impacts such as greenhouse gas emissions per capita (McGranahan and Satterthwaite 2014). To maximize the multiple benefits of the compact city form, a paradigm shift is needed in the way that cities are shaped and governed.

The second challenge identified in discussions is the need to review and revise the way we live in, design, and manage our cities. Shocks and stresses affecting cities now and in the future pose significant threats to humans and ecosystems. In many cities, potential shocks — such as extreme weather events related to climate change — are not yet being sufficiently addressed through infrastructure and institutional development. Similarly, stresses, which may be slower to manifest but equally damaging, such as insufficient water supply, poor air quality, and shortages of natural resources due to unsustainable consumption and production, are also not incorporated in the design and/or management of cities. City design, planning and management decisions need to be based on a longer-term vision.

Policy areas

Most cities lack the resources and capacity to effectively tackle the specific barriers to urban environmental sustainability and resilience. This paper identifies policy areas that are critical to building the vision espoused in this document.

Current literature points towards a lack of understanding of resource flows and patterns of consumption and production as one of the barriers to urban environmental sustainability. There is also a need to develop locally appropriate ways to protect and support ecosystem health. Examples include investment in

green infrastructure and nature-based solutions, provision of diverse open space, a shift to reliance on renewable energy sources, and improved options for transport such as walking, cycling, and mass transit.

Lack of a thorough understanding of risks and vulnerabilities is a barrier to resilience. By using tools such as hazard assessments for relevant current and future stresses and shocks, cities can then design and implement measures that will prevent or mitigate the impacts of disturbances. Fundamental aspects of resilience such as redundancy of urban infrastructure, flexibility of urban space, and inclusive communities should all be integrated into urban planning and management.

Cross-cutting systemic challenges also hamper the formulation and implementation of policies that promote urban environmental sustainability and resilience.

Challenges of governance include the interdependence of different levels of government (e.g. neighbourhood, city, state, national, regional, and global). Institutions often struggle to find ways to work effectively and efficiently with others at different levels. Vertical and horizontal policy integration will be critical.

At the global level, common indicators (e.g. shared between the Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction 2015-2030, and potentially the New Urban Agenda) are expected to improve comparability and reduce the reporting burden on cities, but this has yet to be implemented by a broad range of stakeholders.

Participation of the broader population and particularly the inclusion of marginalized groups such as women, youth, and indigenous peoples is also a key issue. Engaging with the most substantial cross-cutting set of power relations that shape the different experiences in and influence on the urban environment is critical to achieving urban environmental sustainability and resilience.

The role of knowledge management and access to information is another cross-cutting concern. Additional research and analysis is needed to help shape and inform policies on urban environmental sustainability and resilience. A design approach which foregrounds the local is a powerful but underused tool to address environmental improvements that can be co-beneficial to the everyday lives of people and to strengthen their resilience in case of shocks or stresses. Education and awareness-raising are also essential so that urban residents of all ages can become active participants in the co-creation of a healthy, resource-efficient and resilient city.

A New Urban Agenda

Policy paper 8, on urban ecology and resilience, explores the challenge of managing both environmental and human well-being, and the critical role of cities in meeting this challenge. It proposes that a city can be designed and managed to provide multiple benefits that contribute to quality of human life while improving resource efficiency and reducing overall environmental impact.

The authors of this paper recognize that policy paper 8 is only one of many inputs to the New Urban Agenda, and several distinct policy elements are needed in order for us to achieve global goals. Thus, other policy units and issue papers produced through the Habitat III process are referenced throughout this document.

Issue papers 14 (Urban resilience), 15 (Urban ecosystems and resource management), 16 (Cities and climate change and disaster risk management) and 17 (Urban infrastructure and basic services, including energy) are key references for this policy paper. Particularly relevant themes include social equity and inclusion (Policy Units 1 and 2; issue papers 1 and 2); urban spatial strategies (Policy Unit 6, issue papers 8, 9, and 10), and the long-term economic implications of continued growth (Policy Unit 7).

I. Vision and framework of the policy paper's contribution to the New Urban Agenda

1. By 2050 there will be about 9.7 billion people sharing the Earth's resources, 66 per cent of whom are expected to live in urban areas (UNDESA 2014; 2015). With this growth in urban population and expansion of cities, the relationship between human settlements and ecosystems is increasingly vital, both in terms of environmental sustainability and vulnerability to shocks and stresses.

2. Policy paper 8, on urban ecology and resilience, explores the challenge of managing both environmental and human well-being in this context, and the critical role of cities in meeting this challenge. It proposes that a city can be designed and managed to provide multiple benefits that contribute to quality of human life while improving resource efficiency and reducing overall environmental impact. The paper recognizes opportunities for change that will build on the distinct challenges of diverse cities in developed and developing countries, which vary in size, form, physical and cultural context, and level and types of vulnerability.

3. Applying the "urban ecology and resilience" frame demands a long-term view where cities examine their consumption patterns and the flow of key resources (e.g. food, water, waste, building materials, energy) in the specific dynamic contexts of local environment, society and culture. Resilience thinking also encourages us to both anticipate and respond to pressures and threats in ways that can improve the short- and long-term well-being of humans and ecosystems.

A. Urban ecology and resilience

4. This paper considers the concepts of urban ecology and resilience as fundamental to well-being and transformative change. The two concepts are inherently intertwined — indeed resilience thinking emerged from ecology and the principle that cities are unique and complex systems. It is this systems thinking that Policy Unit 8 views as essential to creating cities that meet the life and livelihood needs of all of their citizens (see annex I, Glossary for the definition of systems thinking used in this paper). Through a systems approach, stresses and shocks can be evaluated holistically to understand which pose the greatest long-term threats to the health of cities and their habitants — such as climate change, energy demand, social cohesion, economic stability, governance, access to natural resources (especially water), and population growth.

5. Urban ecology is the systems-based understanding of biotic and physical elements that occur in urban areas. It recognizes the interactions between natural systems and social and cultural systems, among others. Urban ecology places

particular importance on the primacy of natural systems in contributing to livelihoods, well-being and resilience, and focuses on the interdependence of key resources (such as food, water and energy) and their impact on city development.

6. In discussions related to the development of this policy paper, the experts and co-leads found it necessary to include a broader discussion of environmental issues linked to sustainability, which will be a critical element in the New Urban Agenda. "Sustainable" is defined as the state wherein natural systems function, remain diverse and enable the ecosystem to remain in balance. Urban environmental sustainability often refers to the outcomes of policies and actions that arise from urban ecology.

7. Resilience is a complex and dynamic system-based concept used differently in a variety of disciplines, and also a simple concept referring to the ability of a system to return to a previous or improved set of dynamics following a shock. It also refers to the potential for individuals, communities, and ecosystems to prevent, absorb, accommodate and recover from a range of shocks and stresses. At the urban scale, resilience requires investment in man-made and nature-based "hard" infrastructures, as well as "soft" systems such as knowledge and institutions. The concept of resilience when applied effectively can provide a useful base for more substantial changes in the underlying social, political and economic drivers of risk and vulnerability.[1] Factors that influence resilience of cities include their organizational structures, functions, physical entities, and spatial scales. A resilient system can continually survive, adapt and grow in the face of resource challenges and disturbances in an integrated and holistic manner for the well-being of the individual and collective. Those challenges and disturbances may be discrete and temporary, such as a natural disaster, or endure over a longer period, such as a shift in climate conditions or change in availability of key resources.

8. The concepts of urban ecology and resilience are framed by the interrelationships between communities and the natural and built environments at local, regional and global scales. The dynamic between these changing entities is fundamental to resilience thinking and underpins the intentions of resilience: to understand and strengthen a city's capacity to mitigate, adapt to, and recover from internal and external shocks and stresses.

9. The outcomes of improving urban ecology and resilience invariably have multiple benefits, which cut across society, culture and environment. For example, zones within a city that are prone to flooding can be transformed into protective green infrastructure that manages flooding and becomes an important source of locally grown food or water, or a recreational space that enhances community ties and physical and mental health.

10. Urban metabolism, urban nexus, productive cities, regenerative cities, resource-efficient cities, nature-based solutions and low-carbon cities are all concepts related to urban ecology, urban sustainability and resilience. All of these emphasize the need to articulate viable pathways for transitioning urban economies to achieve improved well-being and environmental justice by transforming

[1] The Inter-Governmental Working Group on Indicators and Terminologies is reviewing the definition of resilience as stated in the "Working Background Text on Terminology for Disaster Risk Reduction".

dependence on non-renewable materials to more resource-efficient and renewable flows and better management of ecosystems.

B. Relationship to global policy processes

11. This paper's discussion of urban ecology and resilience is relevant to the achievement of the United Nations Sustainable Development Goals. The Sustainable Development Goals underscore the importance of joint action — including by local governments — to address global environmental issues. While all the Goals have important links to the topic of this Policy Unit, thematically, the discussion in this paper is most relevant to Goal 2 on food security; Goal 3 on health, Goal 6 on sustainable management of water; Goal 7 on sustainable energy sources; Goal 9 on resilient infrastructure; Goal 11 on sustainable and resilient human settlements; Goal 12 on sustainable consumption and production; and Goal 13 on climate change (see sustainabledevelopment.un.org/sdgs).

12. In addition, the Sendai Framework relates specifically to resilience by providing a global blueprint for managing disaster risks (see unisdr.org/we/coordinate/sendai-framework). Its first four targets: to reduce (a) mortality, (b) affected populations, (c) economic losses, and (d) damage to critical infrastructure, also align closely with several targets of the Sustainable Development Goals. Both the Sustainable Development Goals and the Sendai Framework principles and approaches to adaptation are fully embedded in the Paris agreement adopted at the twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21).

13. This paper builds on the gains of COP21, which speak to a change in the way we invest in infrastructure and shape our cities. Policy recommendations in this paper support COP21 targets such as the decision to invest in renewable energy for 78 per cent of new power generation investments by 2030 in major economies (Mabey et al. 2016). COP21 also reached crucial agreements on issues such as national contributions to mitigation and global financing for adaptation measures, which set out guidelines and resources for cities investing in ecological health and resilience.

14. The paper is also in continuity with the broader process towards sustainable urban development. It is in line with the Istanbul Declaration on Human Settlements (Habitat II), that emphasizes parties' commitment "to sustainable patterns of production, consumption, transportation and settlements development; pollution prevention; respect for the carrying capacity of ecosystems; and the preservation of opportunities for future generations […] in order to sustain our global environment and improve the quality of living in our human settlements".

C. Vision: sustainable and resilient city

15. Habitat III is an opportunity to reimagine our cities and this paper attempts to articulate a vision of the future city in this section. This vision was developed with a common understanding that cities need to be seen from a holistic perspective — physical, governance, economic, cultural, and societal systems.

16. Considering the environmental and socioeconomic challenges the world faces today, it is imperative that the city of the future be environmentally sustainable and resilient since this is crucial to maintaining and promoting overall quality of life. With this in mind, we envision that:

(a) The city of the future will be the product of conscious investments of the cities of today to build infrastructure and good urban form that promotes accessibility, equality, mobility and cultural identity. Participatory processes will be used, accessing the knowledge and experience of all residents, to design and transform cities. Because of the key role they play in urban life, women will have equal opportunity to participate in decision-making;

(b) The city of the future will be structured to minimize the adverse impacts of the city's overall consumption and production on ecosystems within and beyond its borders, and to contribute to meeting regional and global sustainability goals. It will optimize the sustainable use of environmental resources and mitigate and manage climate change impacts;

(c) The city of the future must be built in consideration of global environmental changes so that it is capable of adapting to, mitigating, and preparing for the various shocks and stresses it faces. These include new and re-emerging diseases, changes in food sources and food security, insufficient quantity and quality of water resources, more frequent extreme weather events, sea level rise, loss of biodiversity, and population pressures from migration;

(d) The future city will have nature-based infrastructure that not only provides a broad range of ecosystem services, reduces pollution, and improves contact with nature, but also provides opportunities to strengthen social cohesion. It will be a city that protects and conserves water resources, is fuelled primarily by renewable energy, and is able to meet growing demands in an environmentally sustainable, cost-effective, resource-efficient and secure manner.

17. To realize the vision of the sustainable and resilient city, there needs to be a global paradigm shift. City leaders, practitioners, city residents, and national leaders need to embrace systems thinking and recognize the interdependencies and interconnections across physical scales and between policies, actions, and effects. There needs to be a conscious effort to introduce this thinking into local practices and education systems.

18. Policy Unit 8 also supports the vision of Policy Unit 7 that argues for cities to consciously address issues of social equity and long-term economic development. A cross-cutting approach will ensure that these issues are addressed in an integrated manner, so that the visions and actions do not conflict. This Policy Unit also references Policy Unit 3, which emphasizes integrated planning, and policy. The future city should integrate planning at various scales — plot, neighbourhood, district, city boundaries, city region, national, regional and global — as all of these will affect sustainability and resilience. Legal and institutional development, governance and policy coordination (Policy Units 3 and 4) should accompany technological innovation towards strengthened resilience, increased community participation and responsibility, and reduction of environmental impact. Recommendations of Policy Unit 6 on integrated spatial planning and management, including rural-urban linkages, appropriate land tenure systems, and access to safe

and inclusive green and public spaces are also closely linked to Policy Unit 8 priorities for improved urban ecology and strengthened resilience.

II. Policy challenges

19. The policy challenges and priorities outlined in the next two sections are categorized into two types: those specific to urban ecology/urban environmental sustainability and resilience which address particular tangible physical, social, institutional or economic outcomes; and cross-cutting process-oriented subjects which address challenges and priorities of urban ecology and resilience, and are also critical to other aspects of the New Urban Agenda. Notwithstanding the enormous diversity that exists from city to city and within the local conditions of cities, there are certain outcomes described in sections II and III of urban ecology/urban environmental sustainability and resilience, which are broadly shared, and can benefit from common tools, such as the use of nature-based solutions and disaster risk assessments. At the same time, to ensure relevance for a global audience, many of Policy Unit 8's recommendations relate to cross-cutting measures that should be in place to ensure, for example, effective governance, inclusivity, and use of design thinking, in order to help every city to develop appropriate local strategies. Implementation (as discussed in sect. IV) suggests ways to integrate tangible solutions and cross-cutting measures to ensure local relevance and efficacy.

A. Challenges to urban ecology and resilience

20. Cities face a number of challenges to their capability and capacity to provide healthy and resilient habitats for humans over the long term.

21. Potential shocks have a wide range of natural and social causes, from increased annual flooding to massive global migration, an issue discussed in detail in issue paper 2 on migration and refugees in urban areas.[2] Today, a large share of the global urban population is also highly vulnerable to environmental hazards, such as extreme climatic events resulting in increasingly frequent and intense droughts and floods, sea level rise and storm surges, and extreme heat; or other natural hazards such as earthquakes, tsunamis, landslides and flash floods. A heavy reliance on distant sources for energy, water, food, and goods has also made some cities vulnerable to sudden disruption of supply.

22. In addition to unpredictable and sudden shocks, cities also need to cope with numerous forms of stress. Consumption and production patterns exceeding the ecosystem's regenerative capacity and planetary boundaries cause resource depletion both within and outside the immediate urban area. Land-use change and land degradation patterns affect local and regional climatic and ecosystem patterns, reducing resilience and causing irreversible ecosystem damage. Air, water and soil are contaminated due to ineffective waste management systems, affecting human health and ecosystem function. Most cities rely primarily on unsustainable energy sources to meet daily residential and industrial needs, resulting in indoor and

[2] Issue paper 2 argues that "planning for and effectively managing migration and displacement is critical to promoting productive, socially inclusive, resilient and sustainable cities" (p. 4).

outdoor air quality deterioration, and a major share of contributions to global greenhouse gas emissions.

23. When considering how to deal with shocks and stresses through policy and planning approaches, policymakers and urban populations are forced to balance competing values such as economic growth, equitable distribution of resources, protection of cultural heritage, resource efficiency, and affordable housing and transport, alongside urban ecology and resilience.

24. It does not help that shocks and stresses are often exacerbated by other issues such as inexorable growth: cities are expanding in places and in ways that ignore or deflate the risks and thereby compound the vulnerabilities. Governance inertia and incapacity is another common issue that aggravates the impact of shocks and stresses. Lack of skills and knowledge, economic instability and the absence of participatory mechanisms magnify these challenges. Often, short-term political cycles or short-sighted economic motives mean that policies and actions do not prioritize a healthy urban ecology. Likewise, conditions are not always right for choices to be made that require an upfront investment, which can generate significant savings in terms of financial and economic returns and protected lives and livelihoods, or a resilience dividend.[3] A range of short- and long-term consequences of climate change complicates the situation even further. They cause physical and financial damage and have negative impacts on human health and well-being, on infrastructure and buildings, and on the health of ecological systems.

25. Due to the numerous barriers faced by city practitioners,[4] the increased exposure and vulnerability of urban populations to shocks and stresses has often been inadequately addressed through infrastructure and institutional development. Today, the planning of resources and capacity to prevent and prepare for damage through early warning and response systems varies. Infrastructure and systems to deliver accessible, reliable, resource-efficient services that are resilient to disasters and a changing climate are often inadequate. Increasing inequality among urban populations causes disproportionate impacts on the most vulnerable and damages the resilience benefits that arise from social cohesion.

26. In spite of these challenges, cities also offer enormous opportunities. In the last decade a growing body of research has demonstrated that urbanization is a key driver of sustainable development. The concentration of people and economic activities that characterizes the urban form allows for major economies of scale; it facilitates the spread of knowledge, culture, and ideas; and it leads to technological and social innovation. At the same time, there is more and more evidence that cities, if adequately managed, also provide significant opportunities to enhance people's resilience and reduce their impact on the environment. While in absolute terms, cities are today a major source of ecological problems, a paradigm shift in the way

[3] The "resilience dividend" has two components: (a) the difference between how disruptive a shock or stress might be to a city that has made resilience investments compared to where that city would be if it hasn't invested in resilience; (b) the co-benefits that investing in resilience can yield to a city that can include job creation, economic opportunity, social cohesion and equity. To realize a resilience dividend, upfront investments are required both in terms of financing and resources. The "resilience dividend" is an "economic leg-up" and allows the city to prepare for the next shock and unknowable circumstances (Rodin 2014).

[4] City practitioners are those involved in policymaking and planning at the city level including but not limited to local government officials, national-level bureaucrats working on city issues, NGOs, and research institutions.

cities are built and governed carries a potential that goes far beyond urban areas. Harvesting this potential of cities to achieve local and global objectives of sustainability and resilience is probably the greatest endeavour of the twenty-first century (among others, see McGranahan and Satterthwaite 2014).

B. Cross-cutting challenges

27. To effectively address the challenges presented above, policymakers must consider and tackle the system- and process-related factors that have contributed to creation of those challenges. While these issues may broadly characterize the overall governance of cities, they are also particularly relevant to the policy processes related to urban ecology and resilience.

Interdependencies of governance

28. The scale of urban ecology and resilience challenges and risks tend to cut across national, regional and metropolitan boundaries, as environmental units of scale such as watersheds do not align with administrative units of governance. This requires coordinated intervention at multiple levels of government, by adjacent administrative units, and by different types of actors, including non-governmental actors such as businesses and individuals. But there are a number of issues that prevent this coordination: appropriate administrative frameworks and mechanisms for cooperation are often missing, making it difficult to achieve a coherent policy intervention, and leaving potential for conflict or gaps in areas of coverage, responsibility and liability; local authorities and local communities often lack the decision-making authority and resources to address their own unique challenges, and may be reliant on state or national guidance or funding; significant differences exist between cities of varying size, age and level of income makes national policy difficult; and, in fast-growing cities, governance frameworks and mechanisms are not always in place, resulting in a decrease in the capacity to plan for the long term and to develop appropriate hard and green infrastructure.

Local participation and inclusion

29. Within cities and communities, there is often limited involvement of diverse local actors in the policy process associated with urban ecology and resilience. This is in part due to the greater economic inequalities in cities (discussed at length in Habitat III issue paper 1 on inclusive cities). Local participation is key to understanding local issues and local landscapes, which are fundamental to the interdependent scalar dimensions of resilience. Of particular concern is the limited input by women, the poor, youth and elderly, physically or mentally disabled, migrants, minority indigenous peoples and others, who are typically the most vulnerable to environmental stresses and shocks, but who also often have insightful perspectives on resilience. Exclusion of private sector actors from the policy process also potentially undermines access to additional knowledge and resources. As a result policies fail to effectively address and prioritize concerns and risks, and may actually increase inequality and environmental injustice. Without mechanisms to enable inclusive and broad-based participation, especially by women and other marginalized groups, policymakers will struggle to gain buy-in and risk failure of implementation.

Knowledge and capacity

30. Limited knowledge about urban ecology and resilience represents a significant challenge, and slows down the process of change and the feedback loops that are essential to resilience. Policymakers and practitioners often do not have an adequate understanding of the principles of systems thinking, and lack a detailed knowledge of the specificities of the local context, e.g. the vulnerability of infrastructure, the built environment, cultural identity, social cohesion, and resource flows and dependencies. Limits of capacity also hold back progress. Urban managers and policymakers need resources to create and implement effective policies towards sustainability and resilience at a neighbourhood and local scale as well as the national scale. Local communities and individuals, in turn, often do not have the capacity to effectively engage in the policy sphere.

Design integration

31. Traditional planning approaches are typically reductionist, single-sector, and linear and do not consider the complexity of interactions in an urban system, which can lead to unintended consequences. Without a systems-oriented approach, such as a local bottom-up design approach that simultaneously addresses physical, cultural, societal and economic issues, urban areas are often not understood as part of their surrounding context, or in terms of the flows of resources, people, water and energy. Ignoring resource flows and the interdependence of urban, peri-urban, and rural areas, as well as the relation between a city and its natural environment, can lead to policies which reinforce and enforce unsustainable resource use. Often, a lack of planning tools and current data makes integration of the design approach into planning and policies challenging.

III. Prioritizing policy options: transformative actions for the New Urban Agenda

32. Meeting the challenges outlined above requires a paradigm shift in the way that cities are perceived, shaped, and governed. City systems must be transformed to encourage healthy, sustainable life and enable the development of communities that can adapt to and prepare for existing/potential shocks and stresses.

33. This paper recommends prioritizing policies that push for a significant change in physical outcomes and can be catalysts of a broader policy process. Ultimately, policies must address the related but distinct goals of a healthy urban ecology and strengthened resilience.

A. Outcome-related policy recommendations on urban ecology and resilience

Optimize urban subsystems and human health

34. Effective management for urban environmental sustainability and resilience potentially provides multiple benefits including economic development, more attractive and liveable urban landscapes, and increased human well-being. These are

elements to a thriving urban subsystem[5] and to what is often referred to as a "healthy city" referring mainly to the positive impacts on human health. Specific policy recommendations to achieve both are as follows.

35. Investment in infrastructure is paramount in optimizing the urban subsystem and prioritizing human health. A key approach would be introducing nature-based solutions into cities.[6] Some key aspects of this are:

(a) Utilizing an integrated "blue-green" approach to water resource management (including black, grey and storm water) and the design of urban green space;

(b) Revaluing and restoration of degraded ecosystems and remediation of contaminated air, water and soil. This will include monitoring air, water, and soil quality and adopting measures to reduce pollutants and particulate matter;

(c) Targeting water quality in coastal and riparian areas is especially important;

(d) Protecting and increasing biodiversity in cities;

(e) Minimizing pollution through effective chemical and waste management, minimizing urban heat island effect and street canyon effect on air pollution;

(f) Providing diverse open and safe public green space which enables cultural, community and recreation activities, and contributes to food and water security.

36. Social systems are also critical to successful nature-based solutions. It is thus important to regularly collect and analyse data on the interaction of ecological and social systems to better understand relationships and "tipping points". Policies should focus on:

(a) Understanding how cities and all their citizens depend on specific resources, measuring urban metabolic flows, and identifying options to promote a more effective and sustainable use of natural resources;

(b) Reducing the production of noise, odour, radiation and vibrations which negatively affect human and ecosystem health.

37. Climate change is among the key challenges that cities face in the twenty-first century. Many of the problems associated with climate change can be addressed at the city level by promoting a low-carbon agenda. This includes:

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[5] The urban system is characterized by the presence of many essential, interrelated elements within a complex structure. To help in the study of the urban system, researchers have divided it into three categories: (a) the "macrosystem", which refers to the city/city system as a whole; (b) the subsystem, which refers to activities (e.g. water systems management) within the whole; and (c) the micro, which consists of individual choice, mostly evident at the neighbourhood level. (Palma and Krafta, 2001)

[6] The European Commission's work on "nature-based solutions" — inspired by or supported by nature — provides case studies of policies that have encouraged city planning and development in this direction. Investing in green infrastructure can also have a positive impact on the social framework of the city. See the European Commission website: https://ec.europa.eu/research/environment/index.cfm?pg=nbs.

(a) Pursuing a locally focused step-by-step approach towards carbon neutrality, setting ambitious targets and actions regarding energy production, energy efficiency, waste management, and carbon sequestration;

(b) Improving options and utilization of sustainable transportation, including priority for non-motorized transport and public mass transit.

Restoring local ecosystems for economic and environmental benefits

As a response to the increased frequency and intensity of hazardous floods in the Mahanadi Delta, Odisha State, India, the State government considered the construction of a dam on the Mahanadi River and commissioned a participatory assessment of its potential effect on nearby Chilika Lake. The assessment revealed that local communities preferred to maintain water flows for their positive impact on agricultural productivity, which more than offset flood-induced damages. Fishing communities downstream also preferred to maintain flows to provide a constant stream of sediment and nutrients that support fishery productivity.

With these considerations in mind, the government decided to implement alternative means to address flood-related risks, while maintaining and regulating water flows. They re-established wetland ecosystem functions, restored degraded ecosystems, and invested in nature-based solutions. These measures proved not only to be the most effective intervention in addressing the negative impacts of the Mahanadi Delta, but also carried significant co-benefits in terms of urban resilience, ecosystem health, and human well-being.

Source: excerpt from Wetlands International, undated — see more at www.wetlands.org.

Shift urban patterns of consumption and production to become more sustainable

38. The consumption and production patterns of cities are a critical element of achieving global resilience and sustainability. Sustainable consumption and production has both environmental and social implications and much of this plays out at the local level. In 2014, humans used about 50 per cent more resources in one year than the planet is capable of regenerating (WWF 2014). This has implications for basic needs such as access to food and clean water, and ultimately to human survival. Attempts to transform our resource consumption patterns need to recognize that this is not just an environmental issue. Inequality is also an important issue that needs to be addressed, with current levels of consumption three times higher for the average European than the average Asian, and four times higher than the average African. Inhabitants of rich countries are often consuming ten times more than people in developing countries (Lorek and Fuchs, 2013).

39. To develop more sustainable consumption and production patterns, it is recommended that local and national government actors:

(a) Use appropriate technology and encourage open use of databases to gather, organize, and manage information on consumption that is critical for developing policies to shift consumption patterns;

(b) Design locally relevant interventions such as compact community models that maximize the co-benefits of economies of scale (e.g. transport-oriented

development, low-energy zones). Initiatives can also take place at the national level, such as France's food waste reduction policy that bans supermarkets from throwing away food products that can still be used;

(c) Ensure that sources of critical resources which are part of a city's basic services and daily consumption (e.g. clean water, food) are secure and protected by policy at all levels of governance. This includes for example, linking watershed management (which may cross administrative boundaries) to the city's environmental plan;

(d) Strengthen the connectivity between urban and rural areas to address production issues. This has an impact on concerns such as food waste as highlighted in issue paper 10 on urban rural linkages which notes that food loss can be reduced by access to markets, storage, and food literacy — a concern both rural and urban (p. 3).

Enhance system resilience to physical, economic and social shocks and stresses

40. Strengthened resilience of city systems enables survival, adaptation and growth in the face of disturbance. Shocks and stresses may be discrete and temporary or endure over a long period, and a more resilient city helps to protect its residents, their cohesion as a community, and their habitat by responding, adapting, and transforming in ways that restore, maintain and even improve its essential functions, structures and identity (see University of Cambridge and ICLEI 2014). Specific recommended policy actions include the following:

(a) Ensure that the city infrastructure and framework are resilient: city planners are encouraged to use creative and inclusive urban planning and design models that include flexible and adaptive use of space, which can minimize adverse impacts of shocks, such as public parks in coastal and riparian zones that also function as flood buffers. Infrastructure investments have to be accessible, reliable and adaptive, meeting long-term demand while ensuring environmental sustainability and climate resilience.[7] Policies should also ensure that houses and buildings, which are important assets of cities, are designed and built to minimize disaster risks;

(b) Invest in "soft" measures, like stronger coordination among diverse actors, development of social capital, or incentives to change norms and behaviours that can contribute to resilience building: this paper strongly recommends, for example, the appointment of a resilience officer at the level appropriate to the local context (e.g. city or metropolitan region) with the responsibility of developing and leading implementation of local strategies. Other measures include education of the general public and encouragement of community-led climate change adaptation solutions. Cities should also adopt and implement the Sendai Framework, including development of national and local disaster risk reduction strategies;

(c) Develop a thorough and detailed understanding of disaster risk in all dimensions of vulnerability, capacity, exposure of people and assets, hazard

[7] Resilient infrastructure is characterized by "redundancy" through spare capacity to accommodate disruption, such as distributed infrastructure networks and multiple sources for food, water and goods. "Adaptability" is also a key trait such as utilizing decentralized and modular approaches to enhance inclusivity and flexibility, for example the use of local renewable energy resources as backup for the main grid.

characteristics and environment: leverage this knowledge for risk assessment, for prevention and mitigation, and for development and implementation of appropriate preparedness and effective response, including early warning systems and contingency plans for critical infrastructure. This should build on hazard assessments for relevant stresses and shocks (such as drought, sea level rise, tsunami, earthquake, flooding, etc.) and test vulnerabilities, first and secondary consequences of failure (including interdependencies between risks and functions) and preparedness;

(d) Protect and create place-specific physical attributes that enhance capacity for adaptation: and that address both the need to prepare for a shock and the need to recover (Allan and Bryant 2011). For example:

(i) A network of diverse spatial types of built form and open space;

(ii) Adequate flat, safe and usable open space as a locus for communities to recover;

(iii) A built environment configured to facilitate community cohesion;

(iv) Population densities and building types that enhance the feedback loops vital for resilience-organization that enables self-sufficiency at local, neighbourhood, city and regional scales and also maximizes the potential for diverse forms of connectivity within and beyond a city.

Ecosystem-based adaptation in Lami Town, Fiji

UNEP has been working with UN-HABITAT, the Secretariat of the Pacific Regional Environment Programme (SPREP) and the local city-council to design and implement an ecosystem-based adaptation strategy for Lami Town, Fiji, to protect the local population from climate change-related threats. As part of the project, a variety of adaptation approaches — ranging from ecosystem-based adaptation options to engineering options were assessed, through least-cost and cost-benefits analysis.

The assessment clearly revealed the important services provided by mangroves, forests, seagrass, mud flats, and coral reefs to reduce flood and erosion, while contributing to development objectives, e.g. by supporting inshore artisanal fisheries. The analysis also showed that an adaptation plan focused on ecosystem-based options, with some targeted engineering options, would result in the highest benefit-to-cost returns, in terms of avoided damages and provision of secondary ecosystem services.

Source: excerpt from Rao et al. 2013.

B. Cross-cutting policy recommendations

41. Processes and context determine how well the policies outlined above can be achieved. There are four important catalysts, introduced in section II.B, that need to be included in policy development.

Interdependent governance

42. Local policies should both inform and implement regional, national and global policy. At the same time they need to embrace global issues in their local context. For example, the global influence of carbon emissions should be considered when local policies are formulated. National policies, in turn, should complement global principles and recognize the unique cultural and physical environments of local areas.

43. Cross-boundary, inter-municipal, and urban-rural cooperation are also essential. Biological and physical effects such as those caused by air and water pollution extend beyond jurisdictional and political borders, and the resilience of a city may be determined by connectivity and resource flows within the region. Appropriate systems should be used to balance interests and facilitate cooperation, such as upstream-downstream water management. Policies should encourage prosperity of all types and sizes of cities, not just the largest.

44. Policies targeting local problems should take into account any potential influence on larger or adjoining geographical areas, and global and national policies should also consider the impacts on specific localities. The importance of local participation in the formation of national and global policies, and vice versa, should be emphasized.

45. Policies should recognize interdependencies through, for example, the following measures:

(a) Account for potential synergies and multiple benefits from broader adjoining places;

(b) Develop national strategies with strong input from and responsibilities for lower levels of government. Examples include: national sustainable urbanization strategy, national resilience action plan, national mitigation and adaptation support programmes for local governments and the Smart Cities programme. Share authority and financing between municipalities or metropolitan areas and state or national government agencies for managing and enforcing land use, property rights and environmental services;

(c) Promote cooperation and coordination among actors at different levels and across borders, e.g. through regional and inter-municipal bodies. Set targets to align various policies towards common goals;

(d) Minimize any conflict between national policies and local community interests;

(e) Encourage cities to join global campaigns, networks and initiatives.

Local participation and inclusion

46. The interdependent nature of urban subsystems places an important responsibility on local governments to guide and manage local activities. Decentralizing decision-making and enabling local communities ensures that the specificities of ecology and place inform decisions on environmental matters. Local participation also forms the basis for social cohesion, provides for and protects diversity, and creates greater equity in knowledge capital within a community: all are essential attributes of building resilience in cities.

47. The transformation of our cities will only be possible through organized and committed participation by diverse actors. As argued in Habitat III issue paper 1 on inclusive cities, "the greater cultural diversity found in urban areas can deconstruct social norms, gender stereotypes, and traditions or customs that [currently] hold women and disadvantaged groups back, thereby reducing associated discrimination" (Habitat III issue paper 1, 2015, p. 2). The essential role that women must play in achieving sustainable and resilient cities, as well as their potential to contribute meaningfully in decision-making processes, needs to be acknowledged. Women and girls should be empowered not only for equity reasons, but also because their capacity to drive change is a key resource that is often underestimated. Governments and multilaterals should also listen to and consider the diverse voices of local communities, including locally elected officials, youth and elderly, persons with disabilities, ethnic minorities, and other marginalized groups, and promote and support local and indigenous practices and solutions to building resilient cities. These different actors, with their own knowledge systems, practices and experiences, each contribute to the diversity of system function as well as the local feedback mechanisms needed to strengthen resilience.

48. Private citizens, businesses and civil society organizations are potentially key drivers of change, and a source of capital and innovation and joint ownership. Urban policies, structure and function should take shape in collaboration with residents and other stakeholders with interests in sustainable, healthy and resilient cities.

Engaging with the most substantial cross-cutting set of power relations that shape the different experiences in and influence on the urban environment is critical to achieving urban environmental sustainability and resilience. This entails particular attention to women, who often have unique and direct experiences with the urban environment, and less opportunity to participate in decision-making processes. This exclusion perpetuates the notion of women, especially those from poor and low-income communities, as passive rather than active agents of development.

49. Policies should promote local participation and inclusion through the following measures:

(a) Allocate responsibility on the smallest, lowest or least centralized level that is reasonable, following the subsidiarity principle;

(b) Create local action bodies with specific tasks and responsibilities, or other opportunities for local actors to contribute and innovate;[8]

(c) Create clear incentives (including financial) for local action;

(d) Develop new and duplicate existing successful models of cooperation between the public, the business sector, and local and national government;

(e) Use mechanisms to identify and engage diverse groups in policy formulation and implementation, especially women, as well as those most vulnerable to environmental shocks and stresses;

[8] Issue paper 1 states, "An essential aspect of ensuring inclusion and meaningful participation by all is through the mobilization of excluded groups themselves whose ability to engage with more powerful stakeholders is greatly enhanced through collective action."

(f) Promote participatory budgeting at all levels;

(g) Create mechanisms to enable participatory urban planning, e.g. for civil society engagement with local government during information generation, design, implementation, and monitoring stages, including the co-production and sharing of data and knowledge about the natural and built environments.

Knowledge and capacity

50. The scientific knowledge that has been developed regarding global environmental trends, ecosystem function, and the availability of natural resources has helped humanity to better understand the natural environment. Cultural heritage and historical memory represent critical knowledge of how a community relates to the natural environment (i.e. what a community has learned from nature, how it has been using nature to thrive, and how it has dealt with moments of crisis). The social habits (i.e. common practices, relationships, and shared norms) that communities have developed need to be further explored, to acknowledge good practices and build on them. Climate change will also require new knowledge of the impacts and consequences on local areas and communities, and climate change models should be adapted and shared with local government to build relevant knowledge. Private sector entities should also contribute their knowledge, skills and resources to the policy formulation and implementation process.

51. Local institutions and grass-roots organizations play a key role to collect, compile, share, and apply knowledge. The combination of scientific knowledge, cultural heritage, and popular knowledge represent an important resource to:

(a) Optimize people's capacities and capabilities with regard to urban ecology and resilience, through development of knowledge, experience and skills;

(b) Drive behavioural change and institutional choices towards more resilient cities and a healthier urban ecology;

(c) Cultivate characteristics of resilience such as the ability to handle surprise, and to apply past learning to new contexts and challenges;

(d) Provide a foundation for better management of natural resources and of the local and global environmental commons;

(e) Create pathways to influence change through the interaction of researchers and decision makers.

52. Policies should build knowledge and maximize utility through the following measures:

(a) Promote research and data collection and analysis on urban ecosystems and resilience; utilize open source software to capture and benefit from new means of collecting data;

(b) Develop a knowledge observatory for cultural knowledge and memory;

(c) Create mechanisms to enable learning from the knowledge, data, and experience of previous stresses and shocks, including disaggregation of data by gender, age, etc.;

(d) Share statistical data between national and local governments at no cost;

(e) Integrate information about urban ecology and resilience into the educational system, from primary through continuing education;

(f) Incorporate traditional and indigenous knowledge into policy formation and implementation;

(g) Implement key concepts, knowledge and skills as orientation for people who are elected to a decision-making position;

(h) Develop planning guidelines for urban ecology, especially considering its role in resilience and disaster risk reduction.

Utilizing new knowledge to mitigate health risks

Changing climate is affecting patterns of vector-borne disease, and public health agencies need to update their community outreach accordingly. A collaborative disease surveillance study in Can Tho, Viet Nam, found that rains are now coming in seasons that were historically dry, affecting mosquito breeding patterns and therefore disease patterns. The Can Tho Project brought together local governments, NGOs and researchers to understand these changes and transform effectively this new knowledge into policies and make health systems more flexible, responsive, and resilient to these changes.

Source: excerpt from Daga 2014, see more at: www.rockefellerfoundation.org.

Design integration

53. Issues of urban environmental sustainability and resilience are increasingly complex, and it is no longer possible to address them with top-down policies or single-issue solutions. One way to acknowledge and manage this complexity is through improved urban design, where "design" is understood to be a process and a set of techniques to deal with issues in a holistic and integrated way. It also offers a medium to achieve greater outreach to small communities where action can take place. It is essentially an activity that simultaneously addresses the bottom-up complexities of everyday life and the top-down implementation of national priorities. Unlike broad planning which tends to be reductive, spatial design can address specificities and thus has more potential to influence behaviour change. Policies should encourage adoption and integration of design processes and principles:

(a) Encourage "nature-based design" based on the principles of energy conservation, reduction of toxic waste and greenhouse gases, diminishing dependence on fossil fuels, and a sensitivity for waste, pollution, and the depletion of the world's resources. This approach works towards total ecological restoration;

(b) Use design to address local environments on a site-specific basis with a thorough understanding of local conditions, natural ecologies, local culture and contextual influences and effects, and based on diagnosis of the city's risks and vulnerabilities and adaptive capacity. Utilize this approach to develop nature-based solutions based on local ecosystems;

(c) Incorporate characteristics of resilience such as modularity, flexibility, and redundancy into the design approach;

(d) Engage local communities in decision-making, framed by resilience goals such as diversity, variability, adaptability and redundancy, and by urban ecology goals such as biodiversity protection, improved water and air quality, and natural habitat connectivity;

(e) Policymakers should work with designers to maximize the value of interventions in terms of relevance and multiple benefits. For example, preventative measures for earthquakes need to be designed so they are part of daily activities, and will therefore be maintained and valued by the community.

Design for resilience and multiple benefits

A successful example of design integration comes from the General Hospital in Karlstad, Sweden, which is located in an area of high flooding risk. To cope with the risk, a levee is being planned that will protect the hospital, surrounding area, and essential roads. The levee will also function as an elevated pedestrian and bicycle path, with a green storm-water management system and surface shutters to let extreme rainfall pass through. This approach creates additional benefits from flooding protection measures by encouraging bicycle use, in line with the municipality's climate and environmental strategy

Source: excerpt from Karlstad Municipality, undated — see more at www.karlstad.se/.

C. Criteria for identifying policy priorities

Criteria for the establishment of priority policies	*Demonstration of criteria*
1. Urgency	Policies should be designed to target the most urgent issues in terms of risk (highest likelihood of occurrence and most severe impact)
2. Impact	The success of any strategy will be determined by its uptake within the community and the potential for behaviour change. To achieve this, all policies should demonstrate not only technical merit, but also their potential to effect change, and should be accompanied by implementation and communication policies
3. Equity	Policies should demonstrate that they can have an effect for all socioeconomic groups especially the most vulnerable
4. Feasibility	Policies should be developed on the basis that they are implementable within strict time frames and available resources
5. Diversity	Policies should demonstrate that they accommodate all cultures, and do not disadvantage any culture
6. Multiple benefits	Policies should demonstrate multiple benefits: e.g. they will have positive impacts across various sectors for sustainability, social equity, and/or environmental health, while addressing vulnerabilities

Criteria for the establishment of priority policies	*Demonstration of criteria*
7. Transformability	All policies and strategies should demonstrate the potential for transformation of communities, not just change of physical environment
8. Replicability	Policies should be implemented on the basis that they can be repeated, with lessons learned also used for future initiatives

IV. Key actors for actions: enabling institutions

54. The actors and enabling institutions needed to achieve sustainability and resilience will be highly specific to the local context but typically include public institutions, civil society organizations and associations, businesses and business networks, and formal and informal networks of residents. This section provides guidance to governments at all levels on how to identify key actors for implementation. Governments should:

(a) Acknowledge the essential role that women and girls have and should have, and identify and address the barriers that exist to their adequate participation at all levels of decision-making;

(b) Consider the existing and potential sources of diverse knowledge (academic, traditional/indigenous knowledge, market-based practical knowledge). Actively include groups with unique perspectives, such as indigenous groups with knowledge systems of society and landscape that help to interpret social cohesion and environmental sustainability;

(c) Enable an enhanced role for the private sector in decision-making and investment, and ensure responsibility for actions. The private sector should be enticed and empowered to be active leaders of positive change;

(d) Identify key contact points for mobilization and communication related to transformation;

(e) Identify the most vulnerable populations. Cities cannot be sustainable when significant portions of the population lack access to basic services and key resources, and are not able to participate in city decision-making;

(f) Understand the use of space and the capacity for its adaptation by people; review spatial relationships and utilization of space by urban residents and organisms; explore the long-term implications of infrastructure decisions for specific groups and communities to understand which actors need to be involved.

V. Policy design, implementation and monitoring

55. This section proposes an overarching implementation framework that policymakers can use as a model of action to support the overall effort towards greater resilience and healthier urban ecology. As presented here, the implementation framework provides guidance for more effective and long-lasting policy interventions, and connects the policy priorities outlined above to the broader context of the urban policy process. The implementation framework has three key

pillars: institutional context, financial mechanisms, and monitoring systems. The three pillars are complementary and closely linked, enabling the paradigm shift that is needed to change the way our cities are built and governed.

A. Establish an enabling institutional context

56. Governments have the responsibility and the legal capacity to establish and strengthen the framework within which different actors operate and interact. The constitutional and regulatory environment they create and enforce is a fundamental condition to enable all stakeholders to play their roles.

Mainstream ecology and resilience concerns into all policies and regulations

57. A key principle of the enabling framework is to incorporate ecology and resilience concerns into all policies and regulations linked to urban development. Ecology and resilience should be anchored into the existing national and local legal frameworks, and cut across all sectors of the urban agenda, ensuring coherence within the policy framework.

Mainstreaming ecology in the institutional setting: merging economics and environment municipal departments

The government of Hannover, Germany, took the step of combining its Department of Environment and Department of Economic Affairs in 2005, which implied a major shift into how local economic development and environmental affairs are managed: not as separated matters but as part of the same agenda. Among other things, merge resulted into greater integration of ecological priorities into economic decisions such as land purchase and allocation. The new department also oversees public relations, to help ensure that public awareness efforts are aligned with the city's ambitious environmental targets.

Source: excerpt from ICLEI and GIZ 2014 — see more at www.iclei.org/urbannexus.

Ensure cross-cutting approaches and exploit all possibilities for multisectoral integration

58. Scarce resources have to be protected, and their use regulated and optimized. To achieve this, we need to strengthen crucial linkages that exist between sectors such as water, energy, and food. Less apparent but equally important are links to mobility, housing and employment, or waste management and energy production. These too must be recognized and considered in policymaking. All policies and initiatives associated with urban development should be designed to maximize opportunities for synergy and cross-fertilization, avoid contradiction among policies, and enhance horizontal cooperation among sectorial bodies and institutions.

Curitiba, Brazil: the "ecological capital" forerunner in Urban NEXUS planning

Curitiba, the "ecological capital" of Brazil, is a world-renowned model for innovative integrated planning and management. Through the institutionalization of an independent public authority (the Institute for Urban Planning Research — IPPUC), the city designs, coordinates and implements cross-cutting solutions to address multiple urban challenges for housing, transport, water and waste management.

Source: excerpt from Cauchois et al. 2014 — see more at www.iclei.org/urbannexus.

Allocate responsibilities to appropriate institutions at all levels

59. Following the subsidiarity principle, each responsibility and associated resources should be allocated on the lowest reasonable level. To ensure implementation, overarching responsibilities should be allocated to the national level (examples include: dedicated ministries, national agencies, national research bodies). Strengthened subnational governments will be key partners to national Governments for implementing sustainable, resilient cities. Strengthening of the subnational level includes: formal and legal responsibilities, the right to generate income (taxes, fees, etc.), human capacity and knowledge. Similarly, at the regional and global scale, the role of city networks to promote exchanges of experience and mutual support among cities and to support joint target setting and action, especially in the fields of ecology and resilience, should be recognized and encouraged.

Creating and empowering inter-municipal cooperation bodies

60. Municipalities of different sizes and characteristics are often interconnected and functionally integrated because of urbanization trends, commuting flows, and ecosystem linkages (e.g. water basins). These connections are dynamic in nature and are rarely reflected by municipal boundaries. In this context, cooperation among government institutions within functionally integrated urban areas needs to be strengthened through innovative institutional arrangements. These include the establishment of new bodies with or without their own governance structures, such as metropolitan areas, regional planning bodies, inter-municipal waste management and transportation boards, etc. Similarly, improving the institutional linkages between urban and rural areas can accelerate the transformation towards ecologically healthy and resilient cities.

Appointment of a Chief Resilience Officer

One critical step cities can take to facilitate their resilience building is to appoint a Chief Resilience Officer (CRO). The CRO is an innovative position in city government that acts as the point person for resilience building, ideally reporting directly to the city's chief executive and helping to coordinate all of the city's resilience efforts. The task of a CRO is to establish a compelling resilience vision for the city, working across departments and with the local community to maximize innovation and minimize the impact of unforeseen events. Examples of cities that have hired a CRO include Bristol, United Kingdom of Great Britain and Northern Ireland; Byblos, Lebanon; Medellin, Colombia; San Francisco, United States of America; Semarang, Indonesia; and Surat, India.

Source: excerpt from Berkowitz 2015, see more at www.100resilientcities.org.

B. Funding and financing urban ecology and resilience

61. One key strategy for financing is to explicitly include funding for urban ecology and resilience measures in the investment and maintenance budgets of urban areas. National and subnational budgets should also be structured accordingly, and the cost of capital should be reduced to create incentives for the private sector and households to participate in urban resilience programmes. The rationale behind creating this type of fiscal incentive is to increase the demand for urban ecology and resilience-related goods and services, expanding their economies of scale, and hence reducing the cost of goods sold. With the increase in demand and consumption, the government will gain tax revenue or at least maintain a balanced or deficit-neutral budget. Governments can also alter incentives to encourage investments in resilience, for example by regulating insurance markets to ensure that post-disaster recovery and reconstruction aid does not discourage purchase of insurance and resilience-building efforts. Post-disaster recovery funds could be partially redirected to building resilience. In addition, local and national budgets may allocate specific funds for disaster risk management.

Innovative mechanisms to increase savings

Finland's Carbon-Neutral Municipalities (HINKU) network is an example of a case where local government managed to reduce expenditures by jointly procuring solar panels. The HINKU consortium, joined by 30 municipalities and cities, launched a call for offers in 2016. The tender process will require a leasing mechanism so that municipalities will not have to make significant upfront investments and operating costs will not increase.

Source: excerpt from HINKU Forum, undated, see more at http://www.hinku-foorumi.fi.

62. Other financing strategies involve different forms of cooperation between national and local government institutions and other actors, such as the private sector, international donors and local communities.

63. Government institutions should promote models of cooperation with the private sector (e.g. new forms of public-private partnerships) to carry out specific urban ecology and resilience agendas. There are diverse possibilities, from availability payments for provision of a public facility to a direct user charge scheme for accessing public infrastructure. Regulatory frameworks for public-private cooperation are already available in many countries, and should be adapted to include ecology and resilience into the bid criteria.

64. International development financing (either grant or loan) for project-specific funding is a complex undertaking and requires a certain capability for receiving national and subnational governments to manage the scheme. A global fund for urban ecology and resilience projects for developing countries could support the implementation of projects or pilot activities for governments, private sector, or community groups, and could help to generate knowledge that would support wider implementation. Transferability and replicability of the projects would be typical criteria for such scheme to gain funding, as would the need to demonstrate financial sustainability of the products/services. Many existing funds do not have adequate modalities to support activities undertaken by subnational governments or non-State actors, but effectively addressing urban ecology and resilience will require mechanisms to support these stakeholders.

65. Initiatives from the local community should be recognized as an important source of funding for urban ecology and resilience initiatives. Community-funded projects should be promoted not only because they create ownership of the projects and assets, but also for the benefit to social cohesiveness, which itself is an important element of urban resilience. There are good practices and well-documented community-funded projects around the world, from traditional collective financing mechanisms to more recent crowdfunding schemes using Internet-based payments. Examples of specific financing mechanisms are provided in annex II.

C. Effective monitoring systems and ambitious targets

Identify and adopt effective measures to monitor performance and track progress

66. Progress towards improved urban ecology and resilience requires a careful analysis of the systems and processes that lead to positive change and that increase the ability to manage shocks and stresses, as well as the measurement of outputs.

67. Monitoring of systems and processes needs to be undertaken in an iterative and reflective manner, paying adequate attention to the quality of policy design and the efficacy of policy implementation. Specific measurable indicators of outputs can be used to track progress towards the ultimate goals of ecological health and resilience. These can include indicators on resource use, consumption, air and water quality, and measures of green space. More specific examples include ecological and water footprints, food supply and wastage, modal share, solid waste generation and disposal. Additional indicators should be used to track social aspects such as community cohesion, which are also fundamental to resilience.

68. In the development of monitoring systems, attention must be given to power relations to ensure that the data being monitored are representative of all — especially marginalized and vulnerable groups. In the case of women for example,

most data are still not disaggregated by gender, which is vital for reflecting the diversity of conditions and impacts.

69. In terms of overall principles, it is important for the monitoring of urban ecology and resilience to be driven by a local perspective and for this reason, this paper does not prescribe a framework of measurement. There is little value — particularly for resource-constrained municipal authorities — in collecting empirical data on issues that are not contextually relevant. Where these issues have significant impacts on local populations, the monitoring and evaluation process ought to also incorporate a significant participatory element in design, data collection and analysis.

70. Monitoring systems should be based on common indicators, to the extent possible, in order to ensure effective use of reporting and reduce the burden on cities. Common indicators between the New Urban Agenda and the Sustainable Development Goals, the Paris agreement on climate change, and the Sendai Framework should be used to the extent possible.

Existing monitoring frameworks

71. An initial stage of the monitoring process is the creation of baselines, although this may be challenging for many cities that do not have significant empirical records on environmental or social aspects. Several of the frameworks referred to in the table below explicitly address these issues, by focusing both on the assessment of systems and on identifying particular quantitative indicators.

Monitoring frameworks for urban ecology and resilience (in alphabetical order)

Monitoring framework	*Key elements covered*	*Source/comments*
carbonn Climate Registry (cCR)	The **carbonn® Climate Registry (cCR)** is the world's leading reporting platform to enhance transparency, accountability and credibility of climate action of local and subnational governments. It is designated to support various programmes, among these the Compact of Mayors launched at the Climate Summit 2014. cCR documents commitments, actions and achievements of local and subnational governments. So far, 8 per cent of the world population is represented on this platform	http://carbonn.org/
City Resilience Framework — Arup	Assesses resilience according to four overarching themes: leadership and strategy; health and well-being; economy and society; urban systems and services. Each of these is composed of a range of sub-themes and a further set of specific indicators	Open access: www.arup.com/cri
EEA SOER indicators	Initiative by the European Environment Agency (EEA), which brings together actors from policy, research and stakeholder organizations to coordinate, integrate and harmonize the numerous approaches for urban monitoring on a European level	http://bit.ly/1pk9w1O
European Green Capital Award	The European Commission identifies the city that shows the most impressive progress in environmental performance across Europe every year, based on a set of indicators and criteria	http://bit.ly/K1cROb
European Green City Index	Compares and ranks European cities according to their sustainability performance and can therefore give insights on how to measure such performance	http://www.siemens.com/entry/cc/en/greencityindex.htm
Findicator	Up-to-date information on key social indicators of Finland, including sustainable development indicators. Includes urbanization, generation of waste and consumption of natural resources. Each indicator provides information in the form of statistical pictures, tables and analyses	http://findikaattori.fi/en
GI-REC/International Resource Panel	The Global Initiative for Resource Efficient Cities (GI-REC) is a platform for collaboration of international organizations, research institutions, city networks, and pilot cities committed to demonstrating that urban metabolism and a systems approach to city management can be operationalized. The Initiative encourages stakeholders to reimagine the lifestyles, processes, and physical structures of cities, to promote more sustainable use of current resources. It also provides avenues for cities to contribute to global environmental goals. GI-REC is currently piloting a toolkit/approach to measure resource efficiency at city level	Unpublished draft available here

Monitoring framework	*Key elements covered*	*Source/comments*
Global Protocol for Community-Scale Greenhouse Gas Emission Inventories	The Greenhouse Gas Protocol provides a robust framework for accounting and reporting citywide greenhouse gas emissions.	http://www.ghgprotocol.org/city-accounting
ICLEI — Local Governments for Sustainability	No direct indicators as such, but projects on indicators have been taking place	http://www.iclei-europe.org/
Local Government Self-Assessment Tool for Disaster Resilience	LGSAT provides key questions and measurements against the Ten Essentials for Making Cities Resilient and builds on the Hyogo Framework for Action. Using the LGSAT helps cities and local actors to set baselines, identify gaps and have comparable data to measure progress over time	http://www.unisdr.org/campaign/resilientcities/home/toolkitblkitem/?id=3
OECD Metropolitan Database/Green Growth Indicators	The OECD Metropolitan Database provides a set of five variables (population, geographic environment, labour market, GDP, patents) and around 20 indicators on the 281 OECD metropolitan areas. The Green Growth Indicators have been selected under four main headings: environmental and resource productivity; the natural asset base; the environmental dimension of quality of life; and economic opportunities and policy responses	http://www.oecd.org/greengrowth/greengrowthindicators and http://measuringurban.oecd.org
Reference Framework for Sustainable Cities	Online toolkit for European local authorities working towards an integrated management approach. Provides guiding questions for assessing projects and policies, and a broad collection of indicators in order for cities to compile their individual set	http://www.rfsc-community.eu/about-rfsc/
Resource Wisdom Indicators for Cities	Indicators include consumption-based greenhouse gas emissions, material losses, ecological footprint, residents' perception of quality of life, etc.	http://bit.ly/21D2JhD
Sustainable development of communities — indicators for city services and quality of life (IS037120)	A set of quantitative indicators covering economy, education, energy, environment, finance, fire and emergency response, governance, health, recreation, safety, shelter, solid waste, telecommunication and innovation, transportation, urban planning, wastewater, water and sanitation	Published by International Standards Organization

Sustainable Development Goals

72. The Habitat III Conference is one of the first global conferences after the adoption of the 2030 Agenda for Sustainable Development. The 17 Sustainable Development Goals agreed upon by world countries will shape the discussion on the New Urban Agenda, which will be instrumental to contribute to the achievement of the Goals at the urban and global levels.

73. The Sustainable Development Goals provide an important opportunity for aligning targets for sustainable and resilient cities (see table below). The universality of the targets associated with the Goals means that they will cover the needs and priorities of a wide range of contexts, and will also enable comparison between places and over time.

74. In addition, the stated aim of "leave no one behind" helps to ensure that sustainable and resilient cities also incorporate an explicit focus on disadvantaged and marginalized groups. Activities that take place in cities will be vital for the achievement of several Sustainable Development Goals (not only Goal 11 with its explicit focus on urban areas, but also Goal 13 on climate change). Similarly, cities will need to engage directly with several of the goals if they are to become sustainable and healthy, low carbon, and resilient.

75. The table below is not meant to represent an exhaustive list but rather illustrates the significance of the Sustainable Development Goals to urban environmental sustainability and resilience. Other Goals are also relevant.

Science-based monitoring and performance tracking in Japan

In 2007, as part of its effort toward sustainability, the Japanese Government committed to becoming a "Sound Material Cycle Society" (SMC). This decision both consolidated a long period of sectoral policy development, and set the stage for integrated planning in the future. The implementation of SMC required a renewed commitment to the 3R principles (reduce, reuse recycle), as a well as science-based methodologies for monitoring and performance tracking purposes. As a result, the material flow accounts (MFA) have become an integral feature of Japanese environmental policy, identifying the whole system of material flows in the national economy and providing itemized overviews for such flows.

Source: excerpt from Fischer-Kowalski et al. 2011 — see more: http://www.unep.org/resourcepanel/decoupling/.

Indicative elements from the Sustainable Development Goals for urban ecology and resilience

Goal	*Target*
Goal 11: Make cities inclusive, safe, resilient and sustainable	**Target 11.2** By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
	Target 11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
	Target 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage
	Target 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
	Target 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities
	Target 11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.
	Target 11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

Goal	*Target*
Goal 3: Ensure healthy lives and promote well-being for all	**Target 3.6** By 2020, halve the number of global deaths and injuries from road traffic accidents
	Target 3.9 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being
Goal 6: Ensure availability and sustainable management of water and sanitation for all.	**Target 6.3** By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
	Target 6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	**Target 7.1** By 2030, ensure universal access to affordable, reliable and modern energy services
	Target 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix
Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation	**Target 9.1** Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all
	Target 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
	Target 9.6 Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States
Goal 12: Ensure sustainable consumption and production patterns	**Target 12.2** By 2030, achieve the sustainable management and efficient use of natural resources
	Target 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
Goal 13: Take urgent action to combat climate change and its impacts	**Target 13.3** Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

Formulating ambitious targets at all levels of government

76. While the adoption of monitoring systems is essential to monitor performance and track progress, this should be coupled with the identification of and commitment to ambitious targets by government bodies at all levels. To ensure effective implementation, these targets should be aligned at the local, national and global level and should be backed by broad consensus. Sample targets include: 100 per cent renewable energy, zero greenhouse gas emissions, zero waste, etc. Ambitious targets can set the direction of current and future action, and are useful to show governmental commitment and to send a clear message to the market. Use of platforms such as the Durban Adaptation Charter is an effective way for local governments to publish their commitments and track progress. Setting ambitious public targets is also instrumental in raising the profile of urban ecology and resilience issues, increasing awareness and contributing to long-term behavioural change.

Integrating ambitious targets in city planning

In its Environment Programme and Environment Strategy of 2009, the city of Malmö, Sweden, set an ambitious target to become climate neutral by 2020, and to run all municipal operations on 100 per cent renewable energy by 2030. This target is regularly reviewed and presented in an annual report, to be commented on by various experts. This allows the local government to monitor developments, identify problem areas and make recommendations on the way forward. All relevant information is published on a website, allowing the municipality to communicate progress, indicate areas for improvements, and increase political accountability.

Source: excerpt from Simpson R. and da Schio N. (eds.) 2013, see more at www.irena.org and www.iclei.org/casestudies.

VI. Conclusion

77. Considering the breadth of knowledge on urban ecology, environmental sustainability, and resilience, it is beyond the scope of this paper to incorporate all aspects of these concepts. Instead, we highlight below key messages that emerged during the experts' discussion and stakeholder review process. The interpretation of these key messages must take into consideration different contexts and local conditions. While principles are shared, there is no one solution to achieving urban environmental sustainability and resilience for all cities.

78. **Urban environmental sustainability and resilience should feature prominently in the New Urban Agenda.** Over the next 20 years, humans will face environmental and resource challenges that are unprecedented in scale and urgency. Addressing urban ecology through proactive investment in environmental sustainability and building resilient systems will be essential to human health and well-being. A significant majority of stakeholder comments on all Policy Unit papers were directed towards PU8, indicating an overriding interest and concern that environmental and resilience issues be included as an essential component of the final outcome document, the New Urban Agenda.

79. **Cities, when built and governed well, can be catalysts of environmental sustainability.** The common perception, especially among those who are not city practitioners, is that cities have a negative impact on environmental resources. Cities, however, also present significant positive opportunities. This paper argues that effective governance, policy, and design processes will enable local governments to contribute positively to urban environmental sustainability and resilience, with impacts far beyond municipal boundaries. Interdependencies between local, regional, and global levels are essential to ensure links between policies, actions, and impacts at various levels.

80. **Effective and inclusive governance of resources and ecosystems is critical to resilience.** Much of the current conversation on resilience is focused on disaster risk reduction and climate change adaptation. These are, without doubt, pressing challenges, but a broader perspective on the governance of key resources through effective and efficient use of resources is essential to inform long-term planning. In this context, resilience needs to also be viewed from the lens of climate change mitigation. This is critical especially for discussions on issues relevant to resources that cities manage — such as food security, access to clean drinking water, air quality, extraction of materials, transport of people and goods, selection of energy sources, and management of waste. The role of the local in this debate is essential, as is the role of all groups such as women, the elderly, the poor and indigenous peoples.

81. **Human health and natural systems are intertwined.** The Expert Group recommends that healthy people and healthy cities should be a major concern in the New Urban Agenda. Issues such as food security, air quality, and access to clean water are only a few of the many issues, which link human health to urban environmental sustainability and resilience.

82. **Built environment investments have to be made with environmental sustainability and resilience in mind.** Buildings, roads, water infrastructure, and other city investments last for decades but budgets are often approved based on short-term political and financial objectives. This paper suggests that investments should focus on the long term, and valuation of multiple benefits over longer time periods often show that the overall cost of more environmentally sustainable options is equivalent or lower. Small investments in design and planning can have a tremendous impact on material selection and use with significant long-term impacts.

83. **Nature-based infrastructure is key for reducing vulnerability and increasing the adaptive capacity of cities.** Physical infrastructure such as roads and utility services need to be accompanied by nature-based infrastructure as an essential component of adaptive capacity.

84. **Effective use of soft systems and design are important processes for building resilience.** Institutions, knowledge and social cohesion are vital to enabling adaptation, response and recovery. Resilience is inextricably linked to the complex and interdependent characteristics of urban systems, with their diverse inhabitants. Progress towards improved urban ecology and resilience requires a careful analysis of the systems and processes that lead to positive change. This includes a broad understanding of stakeholder groups, adoption of measures to monitor performance and track progress, and ensuring that decisions are based on baselines and indicators that are continuously updated. One of the important

processes is place-based design, which can find ways to integrate the particularities of a place and a culture with broader objectives for sustainability and resilience.

85. We conclude by noting that this paper is inevitably limited in breadth and depth. Throughout the discussion and review process, the experts reflected on a wide range of resource-specific and place-specific issues that have been alluded to but not fully addressed in this paper. Resources such as water, energy, and waste — as well the interrelationships of these three — are critical to urban environmental sustainability and resilience. The management of landscape and buildings for food and water security, social cohesion and cultural identity are also key topics that need to be further addressed on a detailed scale. We hope that these key topics will be included and figure prominently in the New Urban Agenda.

Annex I

Glossary

Systems thinking

Replaces linear and positivist directions in urban planning and reinforces the primacy of the relationship between elements and the flow of materials and energy rather than individual elements. The natural, physical, human, cultural, and social environments are linked in systems thinking. It recognizes interdependencies and interconnections between policies and actions, achieving multiple benefits in outcomes that address multiple issues.

Urban ecology

Urban ecology is the systems-based understanding of biotic and physical elements that occur in urban areas. It recognizes the interaction between natural systems and social and cultural systems, among others. Urban ecology places particular importance on the primacy of natural systems in contributing to livelihoods, well-being and resilience, and focuses on the interdependence of key resources (usually water, waste, and energy) and their impact on city development. In Policy Unit 8, the term sustainable urban development refers to the normative outcome of policies and actions related to the urban ecology, where “sustainable” is defined as the state wherein natural systems function, remain diverse and enable the ecosystem to remain in balance.

Resilience

Resilience is a complex and dynamic system-based concept used differently in a variety of disciplines, and also a simple concept referring to the ability of a system to return to a previous or improved set of dynamics following a shock. It also refers to the potential for individuals, communities, and ecosystems to prevent, absorb, accommodate and recover from a range of shocks and stresses. At the urban scale, resilience requires investment in both man-made and nature-based “hard” infrastructures, as well as “soft” systems such as knowledge and institutions. The concept of resilience when applied effectively can provide a useful base for more substantial changes in the underlying social, political and economic drivers of risk and vulnerability. Factors that influence resilience of cities include their organizational structures, functions, physical entities, and spatial scales. A resilient system can continually survive, adapt and grow in the face of resource challenges and disturbances in an integrated and holistic manner for the well-being of the individual and collective. Those challenges and disturbances may be discrete and temporary, such as a natural disaster, or endure over a longer period, such as a shift in climate conditions or change in availability of key resources.

Annex II

Financial instruments for urban ecology and resilience

(In alphabetical order — compiled by Sarah Colenbrander, IIED)

Instrument/mechanism	*Definition*	*Contribution to ecology and/or resilience*	*Examples of cities where implemented*
Carbon credits	A carbon credit is a financial instrument that represents one ton of carbon dioxide equivalent being removed from the atmosphere through sequestration or not being emitted through choice of a low-emission technology. A carbon credit can be sold by the actor who has avoided one unit of CO_2 emissions to another actor, who can offset the reduction against their own carbon footprint	The resources from carbon credits can be used to finance mitigation projects that enhance resilience, such as waste-to-energy infrastructure that both reduces the size of landfills and generates energy that can support development	Chandigarh (India), Hefei (China)
Community Resilience Fund	The Community Resilience Fund (CRF) is a global mechanism for channelling resources to diverse communities in order to operationalize resilience practices and reduce their vulnerability to hazards and calamities. CRF has helped mobilize grass-roots women's organizations living in disaster-prone and high-risk conditions. The Fund operates based on a "Resilience Diamond," a holistic bottom-up strategy connecting four interlinked elements with strategic objectives of strengthening grass-roots women's groups organizing and leadership, and deepening grass-roots women's understanding of the risks that may threaten their communities in order to mobilize them to address these risks through community-led action	For many years, grass-roots women have been viewed as a vulnerable group in the face of disasters. They have been seen as victims rather than actors who can mend and improve their communities. As grass-roots women-led practices spread globally, the need for CRF grows proportionally with its goal of empowering women to emerge as leaders and champions of resilience. CRF is an increasingly important financing scheme for strengthening grass-roots women's capabilities and work	CRF is spearheaded by Huairou Commission and Groots International. CRF operates in 21 countries in Asia (Bangladesh, India, Indonesia, Nepal, Philippines, and Viet Nam), Africa (Ghana, Kenya, Madagascar, United Republic of Tanzania, Uganda, Zambia, Zimbabwe) and Latin America and the Caribbean (Brazil, Ecuador, Guatemala, Honduras, Jamaica, Nicaragua, Peru, Venezuela (Bolivarian Republic of))

Instrument/mechanism	*Definition*	*Contribution to ecology and/or resilience*	*Examples of cities where implemented*
Contingent credit facilities	Contingent credit facilities allow a government body to 'draw down' funds in the immediate aftermath of a natural disaster, such as an earthquake or cyclone. To date, this facility has usually been attached to a larger loan through a multilateral development bank, and the government can access this line of credit only in the event of an emergency	Contingent credit reduces the scale of reserves that a government needs to have available, while ensuring that has enough liquidity to launch an emergency response and begin recovery in the event of a shock. In other words, contingent credit provides a government with the finances to immediately respond to events rather than have to negotiate terms with prospective lenders	Fiji, Peru, Seychelles
Green taxes/ environment-related taxes	Environment-related taxes are defined as any compulsory, unrequited payment to general government levied on tax bases deemed to be of particular environmental relevance	The main rationale of imposing a tax on an environmentally harmful substance or activity is to impose a financial cost to be paid by the polluter, and to use the revenues of green taxes to restore and enhance ecosystem services. This helps to internalize the full costs of economic activities and inform behavioural and business choices accordingly	Delhi (India), London (United Kingdom of Great Britain and Northern Ireland)
Insurance	Insurance is an arrangement whereby an institution agrees to provide compensation for a specified event, such as a hurricane or tsunami, in return for regular payments. This permits cities or other actors to transfer much of their risk to insurers and reinsurers	While households, local governments, businesses and other actors will still bear much of the impact of shocks, insurance transfers many of the financial costs of these shocks to another party. By paying for rebuilding, health care and other costs after an event, insurance can facilitate recovery	Insurance is typically taken out by individual actors (households, businesses, etc.) through commercial insurers, but city governments can support this through information and enabling financing mechanisms
Municipal green bonds	A municipal bond is a security or debt obligation issued by a local (usually city) government. The investor effectively lends money to the local government, in return for which they are paid a specified amount of interest until the bond's maturity date, when the	A municipal bond raises the finance for local governments to invest in infrastructure. The green label requires that this infrastructure has a positive impact on the environment, i.e. the resources cannot be used for business as usual infrastructure. Green municipal	Gothenburg (Sweden), Johannesburg (South Africa), Spokane (United States of America)

Instrument/mechanism	*Definition*	*Contribution to ecology and/or resilience*	*Examples of cities where implemented*
	principal is repaid to the investor. For a 'green' municipal bond, the loan must be used to finance environmentally friendly infrastructure	bonds have been used for bioenergy, solar and wind power, improving the energy efficiency of buildings and low-carbon public transport systems (e.g. hybrid buses)	
"Pay as you save" and "pay as you go" schemes	"Pay as you save" and "pay as you go" schemes aim to spread the costs of infrastructure over a substantial period of time. A body with large financial resources provides the capital investment, and is repaid in small instalments by the user/owner	"Pay as you save" and 'pay as you go' schemes help to finance the high upfront costs of new infrastructure that can enhance resilience. For example, it can fund retrofitting to improve building efficiency so that households are less vulnerable to extreme temperatures and energy price shocks, or it can fund new infrastructure to improve households' access to energy and water	"Pay as you save" is widely used in the United Kingdom to cover the costs of refurbishing houses to improve their energy efficiency. "Pay as you go" is widely used in sub-Saharan Africa to cover the costs of solar home systems
Payment for Ecosystem Services (PES)	PES are incentives offered to landowners in exchange for managing their land to maintain or enhance specific ecosystem services	PES can be used to improve financial returns for landowners with incentives to conserve particular ecosystem functions, e.g. rainwater infiltration to reduce flooding	Examples of developing countries that have adopted PES include Brazil, Costa Rica, Uganda and Viet Nam
Transferable development rights (TDR)	TDR is a land zoning or planning tool used to manage spatial development by redirecting new developments to sites that are less socially, culturally or environmentally sensitive. Essentially, the right to develop one particular area (the "sending area") is transferred to another area (the "receiving area"). The person or institution that owns the sending area is compensated for the loss of those development rights with a share of revenue generated from development in the receiving area	TDR provides a way to protect ecosystems that contribute to resilience, such as wetlands that absorb excess run-off during heavy rains and therefore reduce flooding. TDR has also been used in Mumbai to protect informal settlements from being relocated and to generate revenue for upgrading	Hong Kong (China), Mumbai (India), New York (United States)

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