U20
RIYADH 2020
URBAN

Resilience in the Anthropocene

Mainstreaming Nature-based Solutions to Build Resilient Cities

Nature-based Urban Solutions

Contents

About Urban 20

Urban20 (U20) is a city diplomacy initiative that brings together cities from G20 member states and observer cities from non-G20 states to discuss and form a common position on climate action, social inclusion and integration, and sustainable economic growth. Recommendations are then issued for consideration by the G20. The initiative is convened by C40 Cities, in collaboration with United Cities and Local Governments, under the leadership of a Chair city that rotates annually. The first U20 Mayors Summit took place in Buenos Aires in 2018, and the second took place in Tokyo in 2019. For 2020, Riyadh City is the Chair city and host of the annual Mayors Summit. The first meeting of U20 Sherpas was convened in Riyadh, Saudi Arabia, on the 5th – 6th February during which the foundations were laid for the U20 2020 Mayors Summit in the Saudi capital later this year.

About the Urban 20 Taskforces

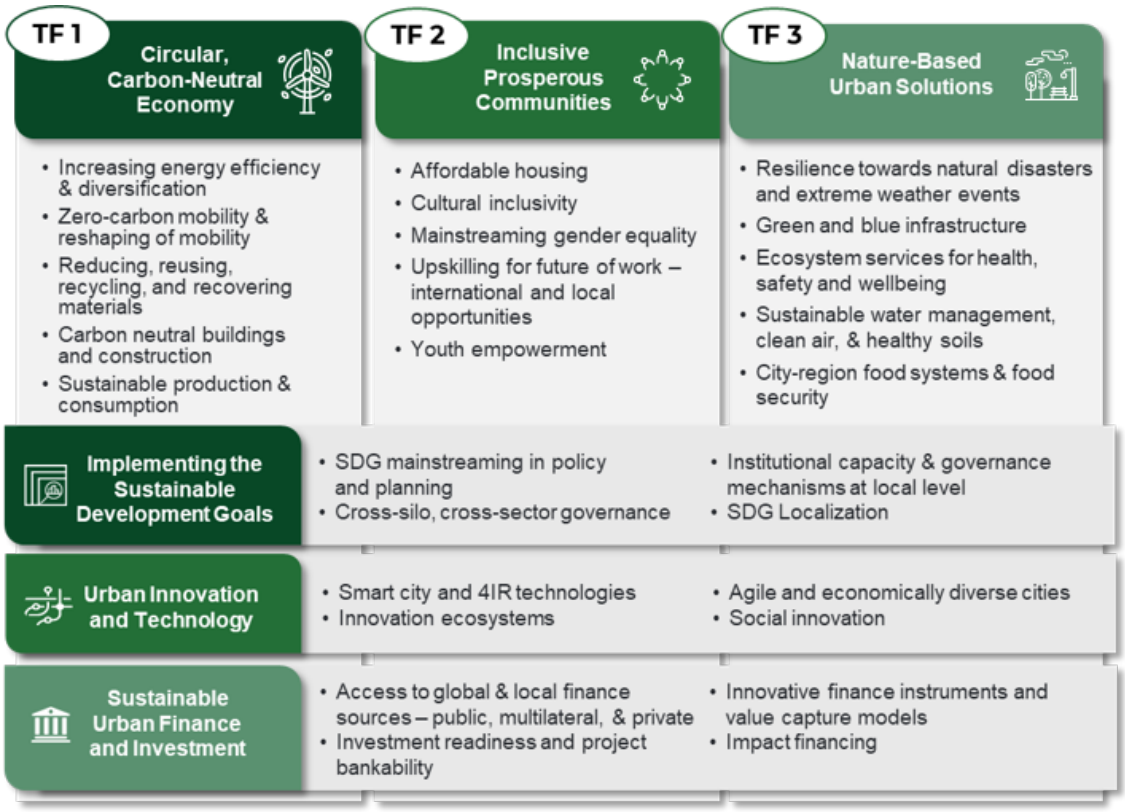
As U20 Chair, Riyadh has introduced taskforces to add additional structure and focus to the U20. These taskforces explore specific priority issues and bring evidence-based solutions to the final Communique.

Each taskforce has commissioned whitepapers led by chair cities, and with input from participating cities and knowledge partners. These whitepapers help us build an evidence-based, credible and achievable set of policy recommendations.

Taskforces activation

The taskforces workstream was an innovative and recent introduction to the three-year-old U20 initiative by the chairmanship of the city of Riyadh this year. Three thematic taskforces, each guided by one of the U20 Riyadh 2020 overarching themes of Circular, Carbon-neutral economy, Inclusive Prosperous Communities, and Nature-based Urban Solutions, were officially launched and activated during the U20 First Sherpa meeting back in February. During the meeting, the U20 priority topics that fell within the three overarching themes and intersecting with the three cross-sectional dimensions of Implementing the Sustainable Development Goals, Urban Innovation and Technology, and Urban Finance and Investment were prioritized and refined through the statements delivered by all attending cities. The top 5 topics were then chosen to be the focus of whitepapers for each taskforce.

The top 5 topics under each of the three taskforces and cross cutting dimensions were then chosen to be the focus of whitepapers for each taskforce:



Cities and Partner Engagement

The vast majority of the twenty-three cities who attended the first Sherpa meeting, representing 12 G20 countries, along with the U20 Conveners, agreed to the importance of having taskforces as interactive platforms to produce knowledge-based and evidence-based outcomes that can effectively feed into an actionable U20 Communique. During and following the meeting, several cities demonstrated interest in volunteering in the capacity of chairs and co-chairs, leading and overseeing the activities of each taskforce. The cities of Rome and Tshwane co-chaired Taskforce 1 on Circular, Carbon-neutral Economy, Izmir Taskforce 2 on Inclusive Prosperous Communities, and Durban on Nature-based Urban Solutions. Others expressed interest to participate in the taskforces, some in more than one, both during and after the meeting.

Alongside interested U20 cities, several regional and international organizations proffered to engage in the work of the taskforces, in the capacity of knowledge partners, to share their knowledge and experiences with cities in producing whitepapers. Some of the knowledge partners volunteered to play a leading role as Lead Knowledge Partners, supporting the taskforces' co/chairs in review and guidance.

All participants who actively took part of the taskforces were subject matter experts nominated by the cities and knowledge partners and have enriched the taskforces' discussions with their know-how and experiences. In over 3 months, all three taskforces, with great effort and commitment from all their participants, produced a total of 15 evidence-based focused whitepapers, bringing about more than 160 policy recommendations addressing the national governments of the G20 Member States.

The taskforces content development efforts is comprised of 23 U20 cities and 31 U20 knowledge partners. The 100+ experts and city representatives produced 15 whitepapers which widely benefited and informed the development of the first draft of the communique.

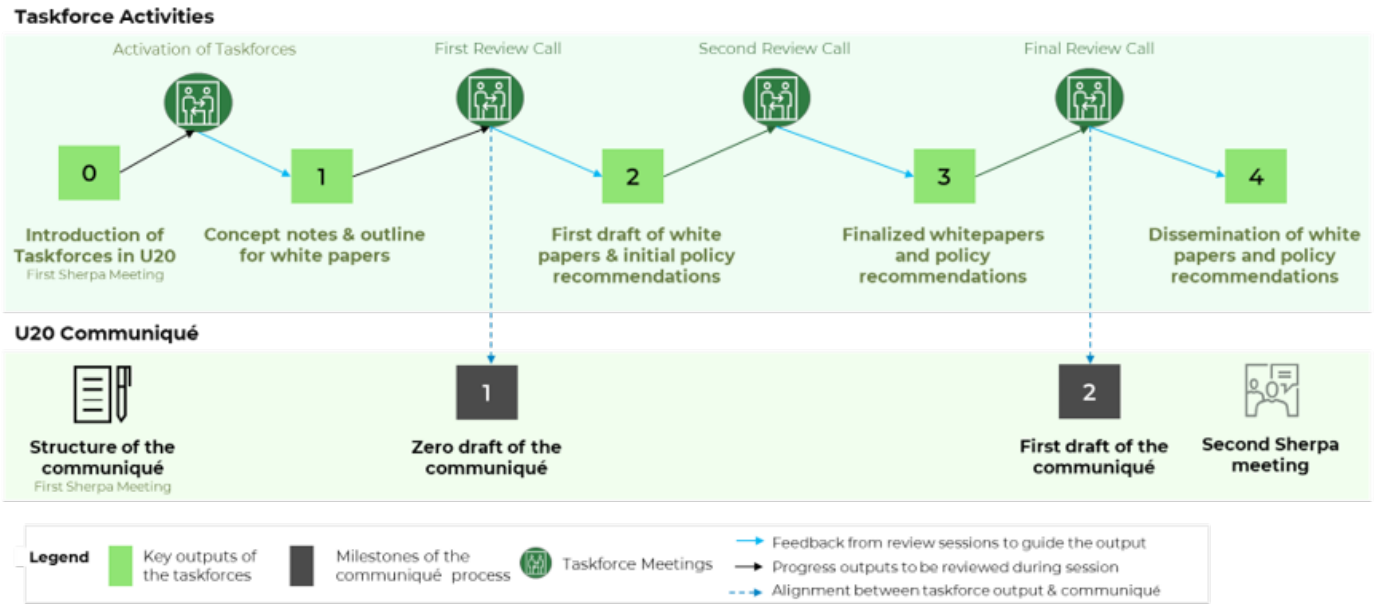
Content Development

Under the leadership and guidance of the chair city, Durban, and the lead knowledge partner, ICLEI, the work of Task Force 3 kicked off with an orientation for all participants in mid-March.

During the period between March and April, the participants of Taskforce 3 presented more than 23 concept ideas and 12 concept notes and developed initial outlines for the whitepapers focusing on topics of interest. Teaming up into six author groupings, the cities and knowledge partners developed six outlines of whitepapers. Refined and revised outlines were then developed into draft whitepapers that underwent several iterations for development and finalization, ensuring that each paper delivers a set of concrete and targeted policy recommendations that address the different U20 stakeholders.

The six whitepapers under task force 3 (listed below) explore priority topics on food systems, urban sanitation and waste management, urban healthy and safety, resilience and biodiversity:

1. Towards transformative change: urban contributions to achieving the global biodiversity agendas
2. Resilience in the Anthropocene: mainstreaming nature-based solutions to build resilient cities
3. Addressing finance and capacity barriers for nature-based solutions implementation at city level
4. Urban health, safety, and well-being: cities enabling the provision and access of ecosystem services
5. Empowering cities for the development of sustainable food system policies
6. Urban sanitation and waste management for all



Along the taskforces timeline of activities, three review meetings were held where co/chairs and lead knowledge partners presented and discussed with the U20 Executive Team the progress and findings of the taskforces they represent, leading to the U20 Second Sherpa meeting that took place during the first week of July. Parallel to the taskforces activities, the first draft of the U20 communique was developed by the U20 Executive team incorporating recommendations presented at the third (and final) review meeting.

About the Nature-based Urban Solutions Taskforce

Nature-Based Solutions need to be mainstreamed in city planning and development to provide a healthy urban environment with productive ecosystem services, such as the provision of clean air and freshwater, food and nutrition, recreation and tourism, as well as livelihoods for local populations and resilience to climate change impacts.

Cities are highly dependent on a healthy local environment and productive ecosystem services. Rapid environmental degradation and biodiversity loss due to climate change, habitat destruction and pollution, threaten the foundation for life in and around cities across the globe. Local ecosystems need to be restored, protected, and upgraded to enable and improve the prosperity and well-being of people in cities. Water and food systems within which the city draws resources from, must be managed sustainably to ensure long-term security. Nature-based solutions like endemic and biodiverse urban greening, ecosystem restoration, green roofs and walls, and natural water-retention methods, need to be mainstreamed and designed in city planning and development, taking into account the multiple co-benefits of policy choices. These can improve air and water quality, provide cost efficient cooling for districts and buildings and increase the physical and mental health of residents. They build the green and blue infrastructure needed for resilience against extreme weather events and the adverse effects of climate change, and attract global talent and sustainable tourism to the city. Nature must be integrated into urban environments. This increases both biological and economic prosperity and productivity, enabling new business opportunities for entrepreneurs and innovators, while providing habitats for biodiversity in harmony with traditional urban infrastructure.

15 cities

U20 Participating cities

Madrid
Mexico city
Montréal
Moscow
Rio de Janeiro
Riyadh
Rome
Sao Paulo
Strasbourg

Chair city

Durban

U20 Observer cities

Amman
Dammam
Helsinki
Rotterdam
Singapore

14 knowledge partners

Lead knowledge partner

ICLEI – Local Governments for Sustainability, Cities Biodiversity Centre

Knowledge partners

- Asian Development Bank Institute
- French Development Agency
- Global Alliance for Health and Pollution
- Inter-American Development Bank
- International Union for Conservation of Nature
- Lee Kuan Yew Center for Innovative Cities
- Metropolis
- National Institute of Urban Affairs
- The Nature Conservancy
- University Bocconi Milano – GREEN Centre
- University of Pennsylvania
- World Economic Forum
- World Wildlife Fund

About the Authors & About the Contributors

Acknowledgement Note

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Ingrid has more than 30 years' experience in sustainability and governance. Her work focuses on mainstreaming nature, its benefits, and nature-based solutions into urban planning and decision-making in cities and city regions thereby helping them become healthier, and more resilient and liveable places. She also serves as technical lead on ICLEI's biodiversity advocacy work. Ingrid's expertise includes stakeholder engagement, facilitation, law reform, policy, and strategy development.

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Executive Summary

Executive Summary

Current urbanization trends are leading to the degradation and destruction of ecosystems and threaten their ability to provide vital benefits to people. The United Nations has declared the next ten years as the Decade on Ecosystem Restoration 2021–2030 to highlight and address the need for greatly increased global cooperation to restore degraded and destroyed ecosystems. This action is crucial to combating climate change and safeguarding biodiversity, food security, air quality, human health, and water supply and quality.

This whitepaper proposes innovative governance, financing and technological solutions to mainstream nature-based solutions in cities to improve ecosystem functioning, climate change adaptation, and human health to improve the resilience of cities and urban communities against natural disasters and extreme weather events. It aims to broaden and strengthen the understanding of decision-makers in the G20, while addressing a range of applicable dimensions by demonstrating how ecosystem health has a variety of benefits for achieving water management and clean air in urban areas with strong positive consequences for human health. It will argue that increased investment in, and access to, finance for innovative and technological approaches to conserving and restoring ecosystems is a necessary precursor to urban resilience. This will require sound governance and the mainstreaming of nature in sector policies, infrastructure, and urban planning. Considering the devastating impact of climate change and environmental degradation on the world population, this paper also proposes the implementation of disaster risk monitoring and prevention policies as a condition for urban resilience. These policies will create an appropriate environment for innovative nature-based solutions to be applied. The whitepaper includes several recommendations that should be put in place to provide the enabling conditions and support for local governments to deliver resilient cities that are safe, healthy, and water secure environments.

Background

Background

The United Nations' World Cities Report 2016, Urbanization and Development: Emerging Futures, predicts that by 2030 two-thirds of the world's population will be living in cities. It further forecasts that the urban populations of developing countries will have doubled and that the area covered by cities could triple. This report also points out that for megacities, the greatest growth will take place in the developing regions, and that medium and small cities, those with less than one million inhabitants, are the fastest growing urban centers.

Current rates of urbanization and growth, together with development trends across the world, increase resource consumption patterns and threaten the health and functioning of ecosystems, with serious consequences for human health and wellbeing. Ambient air pollution alone has been estimated to kill between 3 million and 4.2 million people per year. The continued degradation of ecosystems likewise contributes to climate change and enhances the risk of severe ecological disaster. The loss of functioning ecosystems will negatively impact on the attainment of the Sustainable Development Goals (SDGs), as well as global biodiversity and climate change targets. Unless we drastically bend the curve in biodiversity and ecosystem loss, and change consumption and production patterns to keep within planetary boundaries, many species and ecosystems face extinction. This in turn, will threaten human wellbeing and survival as livelihoods, social systems, and economies collapse.

The United Nations Decade on Ecosystem Restoration 2021–2030 was conceived and launched to highlight and address the need for greatly increased global cooperation to restore degraded and destroyed ecosystems, which in turn will contribute to efforts to combat climate change and safeguard biodiversity, food security, air quality and water supply and quality.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment highlighted the relationship between climate change, biodiversity loss and human wellbeing. The biodiversity and climate crises are two sides of the same coin and cannot be solved in isolation: integrated solutions are needed to solve them together. Mainstreaming and investing in nature-based solutions – such as ecosystem-based adaptation and ecosystem restoration – are perhaps our best chances at solving the two crises simultaneously and improving the resilience of our cities and urban communities.

Since the mid-20th century, climate change has accelerated rapidly due to human activity. Natural disasters and extreme weather events have increased significantly. We now face a new disaster – the COVID-19 pandemic – which threatens our existence, social systems and economies. Under the current trajectory, these disasters and extreme weather events are only set to increase in severity and frequency. In an increasingly urban world, the consequences of disasters and extreme weather events will greatly affect people living in cities. Failure by local governments to address ecosystem degradation and loss of ecosystem services will have catastrophic consequences for our urban economic, social, and environmental systems, and the resilience of urban communities.

Background

The **2019 Urban 20 Tokyo Mayors Summit Communiqué's** joint recommendations to the G20 included climate change as one of the most pressing challenges facing our planet that need to be addressed. The communique called for collaboration between G20 member countries to achieve climate change adaptation goals through, among other things, strengthening resilience and adaptive capacity to climate change by taking the following actions:

- Build and improve resilient infrastructure, decentralize energy supply, increase the use of renewable energy, conserve and restore ecosystems, and develop sustainable food systems in order to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters, and ensure people's health and livelihood, with special consideration for vulnerable people and vulnerable zones such as coastal, rural or underdeveloped areas.
- Support cities by unlocking the necessary resources and encouraging multi-stakeholder engagement in adaptation planning across national and subnational levels of government.
- Step up our efforts to help realize the Strategic Plan of the Convention of Biological Diversity (CBD) and its Aichi Biodiversity targets and scaleup ambition to ensure the success of a post-2020 global biodiversity framework will be adopted at CBD COP15 in 2020 in China.

Introduction

Introduction

Climate change is increasing the frequency and intensity of extreme weather hazards all over the world. According to IPCC (IPCC, 2018), human activities have caused approximately 1.0°C of global warming above pre-industrial levels and, within the next ten to thirty years, it is likely to reach 1.5°C. The rise of the global average temperature entails several environmental hazards, threatening human life. The same study points out that, in 2018, most of the natural events, which affected almost 62 million people around the world, were associated with extreme meteorological and climatic events.

However, the most vulnerable population and low incoming countries, due to geographical location and development gaps, are at the greatest risk of climate hazards. Poor households usually occupy the most fragile lands, subject to, for example, floods and landslides. Climate hazards have the potential to worsen their situation and thereby worsen the social inequalities. Geographical location and development gaps are deciding factors so that low incoming countries are the most affected by climate change impacts.

Ecosystems, if managed sustainably, have the potential to absorb both the harmful by-products of urban processes and the climate shocks that are associated with the perpetuation of these processes. Cities are well positioned to mainstream biodiversity and ecosystem services into planning and development processes, if they are supported to do so by their national governments. However, this requires a systemic, ecosystem-based approach involving collaboration between all levels of government, to deliver nature-based solutions at the city scale. The ecosystem-based approach, endorsed at the 5th Conference of the Parties (COP), is a strategy for the integrated management of land, water, and living resources and is the primary framework for action under the UN Convention on Biological Diversity (CBD).

The first entry point to mainstreaming such an approach is to ensure it is embedded in the system of governance in each context. This can be achieved through mainstreaming nature-based solutions, and specifically ecosystem-based adaptation, into policy frameworks such as climate adaptation strategies, disaster risk reduction strategies, infrastructure policy, planning laws, and public finance policy to influence decision-making, as well as budget prioritization processes in relation to infrastructure development to favor green and blue development.

Secondly, mainstreaming nature-based solutions will help to build the case for increased resource mobilization to attract greater investment from the public and private sectors into nature-based solutions. In a rapidly urbanizing world, both city governments and the natural resources that we all depend on are under pressure to meet increased demand for infrastructure, land, water, and other requirements. Meeting these increasing demands places strain on the financial resources of cities. At the local level, budgets and policies for addressing development and infrastructure challenges, as well as climate adaptation and disaster reduction strategies, are determined by a complex mix of growth and development priorities, fiscal systems, legal mandates, institutional factors and political

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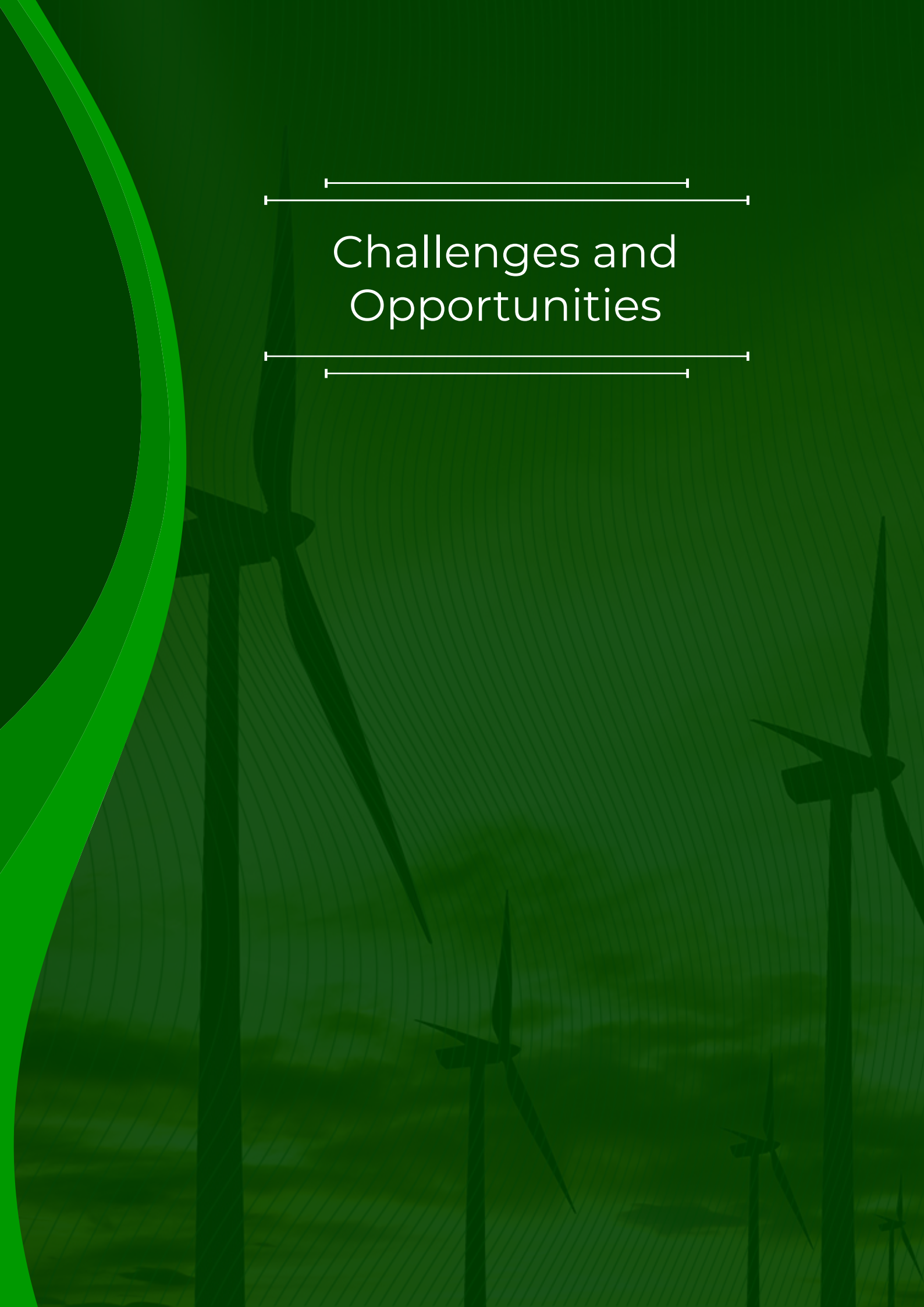
will. Financing for infrastructure development and service delivery in local governments relies largely on intergovernmental transfer payments, grants, subsidies, taxes and other sources that are unsustainable in the long run. The economic benefits and return on investment from urban ecosystem restoration are poorly understood. This is largely due to the fact that ecosystem services are rarely quantified and their benefits are not sufficiently reflected in urban planning. However, there is growing research to suggest that the cost of inaction, in terms of the loss of ecosystem goods and services and the toll on human health, is alarmingly higher than that of investing in green infrastructure and nature-based solutions and restoring ecosystems. Healthy and well-managed ecosystems are economic assets that enhance a city's resilience to natural disasters and extreme weather events. Investing in urban ecosystems and green infrastructure can provide lower-cost solutions to multiple challenges when compared to traditional infrastructure solutions, leading to improved outcomes such as water security and improved air quality.

Thirdly, mainstreaming also requires continued research, promotion, and creation of enabling conditions to enable innovative biotechnology to increase resilience and maximize the quality and functioning of urban ecosystems. Plant and crop resilience and productivity, restoration of degraded soils and ecosystems, and development of vaccines and antibody drugs are examples of how biotechnology has proven itself to provide resilience to our ecosystems and improve human health.

Finally, it is important that efforts and experiences in mainstreaming nature-based solutions are reported and measured to ensure lessons learned and best practices are shared, replicated at scale, and the collective contribution of these efforts towards national and global targets are captured. This can be done on the CitiesWithNature online platform.

Mainstreaming nature-based solutions, and specifically ecosystem restoration and ecosystem-based adaptation, will have cross-cutting positive outcomes for both our society and our planet. The resilience of cities and urban communities in our increasingly uncertain future will depend on our ability to act now and harness the benefits that flow from healthy ecosystems in and around our cities.

Challenges and Opportunities



Challenges and Opportunities

The Current Paradox: Cities in Crisis

Urban Resilience is Critical, Yet Essential Ecosystems are Under Increasing Threat

Our cities are under increasing stress, with many challenges exacerbated by the loss and degradation of valuable ecosystems. The demand on ecosystem goods and services, such as clean water and food production is rapidly increasing, particularly in light of the growing urban population and expansion of city regions. The loss and degradation of healthy, functioning ecosystems severely impacts our resilience to natural disasters, pandemics and extreme weather events, and takes a severe toll on human health. The ability to adjust and adapt in the face of these threats and changes, will determine a city's resilience. [1]

Resilience is the ability or capacity of a system to adapt; organize and grow in response to gradual change or disruptive events.[2] Over the last few years the focus on resilience in international policy and discussions has increased, as the world is confronted with numerous threats and hazards. Cities are not only considered to be vulnerable to these threats and hazards, but also pose a threat to the planet. The complexity lies in finding simple solutions to address issues within the complex and dynamic systems which characterizes many cities.[3] Urban resilience is therefore considered to be an adaptive approach in protecting cities from the increasing threats and hazards. Urban resilience refers to a city's ability to absorb, adapt and rebalance to any changes or disruptions that occur. To achieve long-term urban resilience, the urban planning and development processes require an integrated approach. Inclusion of nature-based solutions into urban planning and development processes can increase and contribute directly to building urban resilience.

Nature-based solutions, such as ecosystem restoration are our best hope at addressing ecosystem loss and degradation and achieving urban resilience in the face of increasing disasters, pandemics and extreme events. Nature-based solutions are innovative approaches using nature to address multiple challenges, such as climate change, food and water security or disaster risk management. Furthermore, nature-based solutions help to protect, manage and restore ecosystems and the associated goods and services, while addressing urban societal challenges and providing environmental, economic, and social benefits[4]. The use and implementation of nature-based solution approaches also addresses various aspects of sustainability.

It is well understood that providing ecosystem goods and services, particularly in urban regions,

[1] Bush, J. and Doyon, A. (2019) 'Building urban resilience with nature-based solutions: How can urban planning contribute?', Cities, 95(102483), pp. 1–8. doi: 10.1016/j.cities.2019.102483.

[2] Ibid; Masnavi, M. R., Gharai, F. and Hajibandeh, M. (2019) 'Exploring urban resilience thinking for its application in urban planning: a review of literature', International Journal of Environmental Science and Technology. 16(1), pp. 567–582. doi: 10.1007/s13762-018-1860-2.

[3] Ibid

[4] Cohen-Shacham, E., Walters, G., Janzen, C. & Maginnis, S. (2016) Nature-based solutions to address global societal challenges, Nature-based solutions to address global societal challenges. Gland, Switzerland.IUCN, 97pp. doi: 10.2305/iucn.ch.2016.13.en.

Challenges and Opportunities

contributes to physical and mental human wellbeing in both times of stability, through the provision of social, cultural or community benefits during times of stress, gradual or sudden changes; through mitigation and buffering cities from impacts from natural disasters or other extreme events[5]. In addition, nature-based solutions ensure that ecosystems themselves are more resilient and dynamic, enabling them to adapt to various environmental changes and stresses, which can include urban expansion. The multifunctionality of nature-based solutions, the approaches are often more efficient and cost-effective over the long-term than traditional engineering approaches, which require constant maintenance and adaptation.[6] There are various approaches that can be used when considering nature-based solutions. These include ecosystem restoration, ecosystem-based adaptation and mitigation, ecosystem-based disaster risk reduction, and green infrastructure approaches. In the context of urban resilience many of these approaches are already used and are often interlinked.

Case Study: Durban Metropolitan Open Space System (D'MOSS)

The Durban Metropolitan Open Space System (D'MOSS) is a network of interconnected open spaces which aims to protect biodiversity and the associated ecosystem goods and services of the Durban Metropolitan area well into the future. These open spaces are under public, private and traditional authority ownership and cover an expanse of approximately 94,000 hectares.[7] The D'MOSS comprises a range of different habitat types across the municipal region from grasslands, estuarine environments and forests. Not only does the D'MOSS conserve some of South Africa's most threatened ecosystems, it also contributes towards meeting national and provincial biodiversity targets. It also provides the residents of the metropolitan area with numerous ecosystem goods and services such as supply and regulation of water, as well as cultural and recreational opportunities. In 2017, it was estimated that the natural and semi-natural areas within the municipal region, which includes the D'MOSS, provide ecosystem services to the value of at R4.2 billion/year.[8] These beneficial services also play an important role in climate change adaptation and mitigation, through regulation temperatures and protecting the metropolitan infrastructure from extreme weather events, therefore making Durban and its residents more resilient.

[5] Secretariat of the Convention on Biological Diversity (2019) Voluntary guidelines for the design and effective implementation of Ecosystem-based Approaches to Climate Change Adaptation and Disaster Risk Reduction. Technical Series No. 93, Montréal, 156 pages.

[6] Kabisch, N., N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, S. Knapp, H. Korn, J. Stadler, K. Zaunberger, and A. Bonn. (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas perspectives on indicators, knowledge gaps, barriers, and opportunities for action, Ecology and Society, 21(2): 39. doi: 10.5751/ES-08373-210239.

[7] eThekwini Municipality, What is the Durban Metropolitan Open Space System [website], (accessed 26 June 2020)

[8] Ibid.

Challenges and Opportunities

2. Embedding NBS and Resilience Responses in Governance Systems

Mainstreaming NBS Into Policy Frameworks

Over the decades, the management of natural environments has seen new ideas and terminologies developed, many of which have been integrated into global policy agreements.[9] In some instances, there have been several policy responses and actions, across various governance scales, to conserve nature and sustainably manage it. The 7th IPBES Global Assessment Report does, however, suggest that the progress and implementation of these policies is not sufficient to reduce the threats on nature and prevent its long-term degradation.[10] Concepts such as the more recent, nature-based solutions, are yet to be adequately mainstreamed into policy frameworks. The mainstreaming of nature-based solutions can provide solutions and benefits for many environmental challenges which threaten human health, wellbeing and biodiversity.

The mainstreaming of approaches, such as nature-based solutions, provide opportunities to both conserve nature and provide socioeconomic benefits,[11] as is demonstrated in Amman where development projects are incentivized to be compatible with environmental protection. According to the IPBES Global Assessment Report, to achieve sustainability at the local, national and global level, inclusive and adaptive governance approaches, multi-sectoral planning and strategic policies, such as those being used in Riyadh are needed.[12] Governments have been seeking ways to enhance urban resilience by reducing risk. Concepts such as ecosystem-based adaptation have increasingly gained attention to increase resilience. In 2004 the Secretariat of the Convention of Biological Diversity (SCBD) developed guidelines for the mainstreaming of The Ecosystem Approach. These guidelines are still relevant and can be applied to the mainstreaming of nature-based solutions. In recent years, urban planning and policy making have also promoted nature-based solutions to ensure ecosystems can adapt to and mitigate negative impacts, whilst conserving biodiversity and improving human health and wellbeing[13]. Mainstreaming nature-based solutions is fundamental to achieving urban resilience and sustainability. Public authorities and

[9] Nesshöver, C., Assmuth, T., Irvine, K.N., Rusch, G.M., Waylen, K.A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., Kulvik, M., Rey, F., van Dijk, O., Wilkinson, M.E. and Wittmer, H. (2017) The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of the Total Environment. 579, 1215–1227. doi:10.1016/j.scitotenv.2016.11.106.

[10] IPBES (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services. S. Díaz, J. Settele, E. S. Brondízio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, and C. N. Zayas (eds.). IPBES secretariat, Bonn, Germany. 56 pages

[11] Ibid.

[12] Ibid.

[13] Raymond, C.M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D., and Calfapietra, C. (2017) A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science and Policy. 77, 15–24. doi: 10.1016/j.envsci.2017.07.008.

Challenges and Opportunities

policymakers in some regions of the world have already integrated the concept of nature-based solutions into various governance frameworks. In addition, the SCBD encourages multi-level and multi-sectoral governance approaches, whereby management can be decentralized to the lowest appropriate level, to ensure greater efficiency, effectiveness and equity.[14]

It is important for the implementation of these governance frameworks and policies to carefully consider monitoring and evaluation processes. Raymond et al. (2017) suggests that embedding nature-based solutions into urban policy and planning, and governance at the local level, requires policy learning and integrating lessons learnt from nature-based solutions implementation, during the mainstreaming process.[15] In addition to this, the mainstreaming process must be participatory, to ensure that various systems of knowledge from different governance tiers, institutions, and sectors are integrated, to develop a policy, which is socially acceptable to a diverse stakeholder group. The involvement of a diverse stakeholder group can also strengthen the planning and implementation of nature-based solutions, across the different sectors and can avoid duplication of efforts.[16]

Case from Amman

Amman, Jordan, has developed a number of city strategies, placing ecosystem-based approaches and resilience into comprehensive city frameworks. The Resilience Strategy was developed in 2017 with five main pillars, one of them being 'An Environmentally Proactive City' with five main goals addressing all aspects of its ecosystem. EBRD will work with Amman to develop a Green City Action Plan (GCAP), planning and investing in its future green development, In The Amman Climate Action Plan, there are actions that aim to increase green spaces to enhance tree cover (by expansion of anti-desertification projects and green urban infrastructure also surrounding the city with a ring of trees to achieve protection from dust and wind), this will reduce heat island effect, improve walkability, and reduce local air pollution.

Environmental Impact Assessments (EIA) of projects have become an important tool for integrated environmental urban management for optimal financial, human, and moral resources to ensure continuous economic development. By protecting the environment today for future generations and in light of the increased global interest in environmental problems and the importance of achieving sound environmental management of natural resources through the concept of sustainable development, Greater Amman Municipality has obligated investors to conduct Environmental Impact Assessments (EIA) for any development projects in order to achieve compatibility between development and environmental protection.

(continued)

[14] SCBD (2019) Voluntary guidelines for the design and effective implementation of Ecosystem-based Approaches to Climate Change Adaptation and Disaster Risk Reduction..; Secretariat of the Convention on Biological Diversity (2004) The Ecosystem Approach, (CBD Guidelines) Montréal: Secretariat of the Convention on Biological Diversity 50 p. doi:10.1080/03670244.1972.9990290.

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Case from Amman

The Greater Amman Municipality also included a system of incentives for projects that achieve compatibility between the environment and development from additional FAR (floor area ratio) and discounts on construction fees and taxes imposed, as well as providing all facilities during the implementation of these projects.

Case from Riyadh - Wadi Hanifah and Wadi As Sulay

The entire Wadi Hanifah valley in the west of Riyadh, including main collecting basin and sub-valleys, represents a natural drainage covering an estimated 4,000 square kilometers. The valley began to suffer from environmental degradation in the 90s and, in order to stop this, the government decided to consider the valley as an environmentally protected area and a special development zone.

Riyadh prepared a comprehensive plan for Wadi Hanifah's rehabilitation and put in place the Flood Management Plan in Wadi Hanifa and Wadi As Sulay. According to the flood management plan, a permanent working group to follow up on execution at critical areas was formed. This is composed of the Riyadh Development Authority, the Ministry of Transport, the Saudi Electricity Company, the Ministry of Environment, Water and Agriculture, the Department of Civil Defense in Riyadh, and Riyadh Municipality. A supreme commission was tasked to prepare the designs and documents to monitore the valley and put it forward for implementation.

Learning from the experiences of Wadi Hanifah, Wadi As Sulay, which serves drainage functions on the east side of the city, is being rehabilitated and is 30 percent complete. Through the Wadi As Sulay project, the city is acknowledging and integrating the wadi drainage basin into its urban planning. Land acquisition policies have been changed and a right of way established for rehabilitation purposes.

Prevention, Monitoring, and Response Mechanisms

Considering the devastating impacts of climate change and environmental degradation on the world population, this paper also proposes the implementation of disaster risk monitoring and prevention policies as a condition for urban resilience. One should highlight that policies are important mechanisms to create the appropriate environment for the development and application of innovative and technological approaches regarding nature-based solutions towards disaster risk monitoring and prevention. They generate legal security and a wider understanding of the principles, goals, guidelines, and tools to be sought by the stakeholders involved in this kind of effort

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so that they go towards ways that benefit the environment and society. Ultimately, by developing assertive policies one can stimulate new patterns of behavior.

Initiatives of prevention, monitoring, and response to extreme weather events are placed as Goal #13 in the United Nations Sustainable Development Agenda, as a tool to combat climate change. Cities must support initiatives of such kind in order to be more resilient.

Case study: Prevention, Monitoring, and Response to Extreme Weather Events: the case of the municipality of Rio de Janeiro, Brazil

Rio de Janeiro City, Brazil, has a tropical climate and is geographically located between the sea and the mountains, which creates environmental conditions for high rainfall levels, a result of which has been severe landslides. For this reason, the city government identified the need to work on prevention, monitoring, and response to extreme weather events. Rio de Janeiro City Hall started to build, along with private partners, an operation center, currently called Rio Operations and Resilience Center (COR), with the main purpose of preventing, monitoring, and alerting the population on emergencies in order to reduce the loss of life and material damage.

Rio Operations Center gathers more than 30 public bodies and institutions to monitor daily and continuously the city's operation in favor of responding quickly and efficiently to emergency situations. This center is also responsible to alert the population about risks and urgent measures in case of crises related to climate changes such as heavy rains and landslides. From COR, the civil defense can activate direct channels of communication to local residents of 102 communities in imminent risks, such as SMS messages and sirens installed in vulnerable areas. This system triggers the eviction process, when necessary, that is supported by trained community agents. Specific initiatives for vulnerable groups, such as children, were also necessary to enhance their capacity to face major natural disasters. In this regard, the Citizen Security initiative was conceived to increase the safety level in schools during natural disasters by developing emergency plans to be adopted by education professionals and students during this kind of situation.

Rio de Janeiro City has been investing, developing and implementing measures to provide its whole population with information about prevention and reaction in cases of natural disasters. The above-mentioned prevention actions, along with COR's role in monitoring and quick response to emergencies resulted in a drastic reduction in the number of occurrences and fatal victims of weather and other incidents, increasing the resilience of Rio de Janeiro.

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Integrating Climate Resilience Approaches with Multi-Stakeholder Involvement

Commitment by non-governmental parties, also financially, to contribute to climate resilience measures in cities is a challenge for city governments. Often these kinds of investments are seen as a government responsibility. Lack of funds is limiting cities from taking an active approach to climate change adaptation. Yet, nature-based solutions can be a driver to involve more stakeholders that take responsibility for co-financing these measures.

Different climate effects in cities ask for a broad perspective and scope of protection measures. Most of these measures can serve more than one goal. Due to its character, nature-based solutions can contribute to multiple objectives in a city, including social and natural environment objectives like increasing biodiversity.

In general, the 'green infrastructure' of a city, like parks and trees along roads and neighborhood streets, but also green banks along rivers and canals, is appreciated by inhabitants. It brings 'nature' into the city, creates relaxing space and reduces the noise of the city. It can also contribute to cleaner air. It contributes directly to social encounters and provides a basis for urban biodiversity. From a climate change perspective, green areas can help to cool down the urban space and create a relatively cooler environment for citizens.

Due to these qualities, existing and new, green and natural spaces within and close to cities can serve different city goals and can even support entrepreneurial aims. City governments aim for social encounters of citizens, increase of citizen's health and want to create places with more comfortable temperatures during hot periods. In addition, sports trainers use parks and green spaces for instruction purposes and entertainment companies are also looking for green, attractive spaces for festivals in the summertime.

Depending on the type of nature-based solution different stakeholders could be interested to be actively involved in their development, especially when it meets their interests directly. If the design of nature-based solutions is done in close relationship with and involves stakeholders, financial contributions become an option. In particular, professional stakeholders, such as nature conservators, water authorities or entertainment entrepreneurs, could be potential contributors.

Case from Rotterdam

In the Netherlands, as well as in Rotterdam, an integrative approach has grown in the last decade involving all government levels, semi-public as well as private stakeholders and citizens. Nature based solutions for climate resilience have been part of the approach on national, regional, and local scale. Broad stakeholder involvement is a starting point and common practice but is also a governance challenge.

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Case from Rotterdam

In Rotterdam, the Riverbanks Program started, combining goals for creation of new green, recreational areas, enhancing pedestrian and cyclist routes and of sailing connections, contributing to Rotterdam's climate resilience and strengthening of cultural-historic characteristics. Through this integrative approach many stakeholders are involved, bringing with them their own interests, experiences, and drive. Local private initiatives, committees, and organizations are explicitly invited to contribute to the vision development and plan-making, leading to supportive cooperation.

A common experience from these programs is that broadening the goals and scope of a program, especially when nature-based solutions are involved, can leverage the feasibility of the main purpose: a climate resilient city. Stakeholders that would not have been involved when a 'technical solution' was selected, for instance flood protection measures, will be interested when broader nature-based solutions are considered. When their interests are met, they will also consider co-financing of projects.

Multi stakeholder involvement asks for an open mind to essentially all kinds of stakeholders in a city and the willingness to involve them as early as possible in program or project development. Knowing their interests and linking the societal challenge of climate change to their occupations and responsibilities is a starting point for successful cooperation. Finally, this multifunctional and multi-stakeholder character of green embankments provokes commitment from decision makers because it links with one or more of their interests.

3. Increasing Resource Mobilization to Attract Greater Investment into NBS

Understanding the Multiple Benefits and Return on Investment From Urban Ecosystem Restoration

Cities, especially those fast-growing urban nodes in Asia and Africa, urgently need to rethink the way in which they approach, plan and prioritize budgets. City governments need to work with nature – rather than against it – when planning and building cities. In order to make this shift towards working with nature and adopting nature-based solutions, the very principles that underpin planning, budgeting and fiscal policy at local level, need to be reviewed or completely turned around. It also means that city governments should compare the full long-term cost of "free" ecosystem services that are healthy and well-maintained with the cost of the loss of hard/conventional engineering solutions.

In other words, city governments need to make a paradigm shift from the dependency on conventional quick-fix options to nature-based solutions including green and blue infrastructure solutions. Cities need to think differently about where to seek the best return on investment.

[15] Ibdem 25.Blumberg, L.R., Dewhurst, K. & Sen, S.G. 2013. Gender-inclusive nutrition activities in South Asia. Vol. 2. Lessons from global experiences. Washington, DC, World Bank.

[16] Ibdem 28

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They should identify the direct and indirect contributions of nature-based solutions, such as the economic value of ecosystem services, and mainstream this into policy and decision-making on infrastructure investment and development. It is well known that investments in urban ecosystem restoration ensure the existence of biodiversity by supplying clean water, reducing erosion, increasing rainwater infiltration, mitigating urban heat island effect through the increase of surface of green areas, in addition to being a means of mitigating climate change by enhancing carbon sequestration.

Among the direct contributions of nature-based solutions, it is important to highlight the job opportunities generated by ecosystem services as a stimulus for investment into NBS. A research article by BenDor et al. (2015) shows that in the United States, the ecological restoration sector directly employed 126,000 workers and generated USD 9.5 billion in economic output annually. A case study from Rio de Janeiro on the Cariocas Urban Gardens project demonstrates the potential of a restoration project in generating income and empowerment, precisely for the population most vulnerable to the impacts of climate hazards as well as structural economic problems. In addition to reduction of poverty, this case study also showed that urban restoration also has the potential to improve food security.[17]

The implementation of economic incentives can also be a catalyst to invest in NBS. The standardizing the economic value of ecological services, the offering of subsidies for environmental restoration or the imposition of taxes on degradation are instruments often used by local governments to directly influence the promotion of nature-based solutions.[18]

As for international commitments, local policies that promote urban ecosystem restoration are in consonance with the Sustainable Development Goal - SDG #15, set by the United Nations at the 2030 Agenda, that propose to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss, as well as SDG #14 on the conservation and sustainably use the oceans, seas and marine resources for sustainable development. By localizing the SDG #14 and #15 through the implementation of nature-based solutions, the cities' efforts address to the achievement of SDG #11 and #13 on strengthening resilience and adaptive capacity to climate-related hazards and natural disasters for cities to become more resilient. In order to do so, the SDG #2 regarding food security and #8 directed to economic growth are also highly important.

[17] BenDor, T. et al. (2015). Estimating the Size and Impact of the Ecological Restoration Economy. PLOS ONE, Vol. 10/6, p. e0128339, http://dx.doi.org/10.1371/JOURNAL.PONE.0128339.

[18] World Resources Institute. Atlas of Forest Landscape Restoration Opportunities. Available at: https://www.wri.org/resources/maps/atlas-forest-and-landscape-restoration-opportunities

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Urban agriculture has been identified by the FAO (United Nations Food and Agriculture Organization) as a fundamental strategy for food security, social stability and environmental preservation in the major urban centers of the planet. Thus, urban community gardens are multifunctional nature-based solutions that respond to a wide range of societal and climate-related challenges. They are directly linked to the Sustainable Development Goals of United Nations #2 (focused on achieving food security, improving nutrition and promoting sustainable agriculture), #8 (based on promoting sustained, inclusive and sustainable economic growth) and #11 (directed to make cities and human settlements inclusive, safe, resilient and sustainable).

Case of Cariocas Urban Gardens, Rio de Janeiro

The Cariocas Urban Gardens was created in 2006 and currently has been established in 43 urban farms: 24 located in municipal schools and 19 in vulnerable communities. It aims at providing access to healthy food in the city's most vulnerable regions, by identifying areas with the potential to hold urban farms and offering local population the inputs and material supplies to develop organic agriculture. Moreover, it provides income generation due to the sale of the production surplus through street fairs by those responsible for food production. At last, it increases green open spaces, enhances vegetation cover and prevents building on risk-prone land, contributing to making cities more resilient.

The Cariocas Urban Gardens project also responds to the need of cities to seek the best investments based on the direct and indirect contributions of nature-based solutions in social, economic, cultural and climate aspects, considering the economic value of ecosystem services as a comprehensive approach. The initiative produces about 80 tons of food yearly without the use of fertilizers, agrochemicals or pesticides and requires an average investment of USD 185,031 per year. Considering that more than 120,000 inhabitants enjoy the benefits of the project outcomes yearly, it means a cost per person of USD 1.54. In other words, it is a small fraction of investment to achieve a wide range of beneficiaries and savings in health, social assistance and civil protection.

In planning, the financial sustainability of projects must be taken into consideration. The initiative provides training, ultimately a new profession, and a monthly grant-aid to 170 urban farmers involved in the project for them to buy the supplies needed. Half of the food produced is distributed among inhabitants, public schools, and elderly daycare centers. The other half can be sold to generate additional income for the urban farmers and to purchase agriculture supplies, enhancing their own initiative, contributing to increasing social inclusion and improving the economies of vulnerable communities. By selling this surplus, they get their main source of income, which gives the initiative its financial sustainability. The grant-aid provided by the City Hall of Rio de Janeiro is just a small support to guarantee they will be able to keep the initiative going.

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Cariocas Urban Gardens, Rio de Janeiro

In order to achieve operational sustainability, policies frameworks have been reviewed. According to the National School Feeding Program, it is mandatory that 30 percent of schools' purchase foodstuffs directly from family farmers and rural family entrepreneurs or their organizations, enhancing their income generation and backing initiatives such as the Cariocas Urban Gardens. Also, the Municipal Policy of Urban Agriculture Support states goals, tools and definitions to be considered. Thus, there was a mobilization of different stakeholders, on national and municipal levels, to make this kind of initiative really work.

Considering the benefits achieved by such a small amount of investment, the urban gardens must be considered as a multi layered low-cost solution to be prioritized in the public management. It must be seen as an economic, social and climate asset as it provides training and creates jobs, increases the level of social inclusion and food safety, as well as enhances fostering environmental education. City governments need to make a paradigm shift from the dependency on conventional quick-fix options and may see the Urban Gardens as an excellent functional option.

Mainstreaming NBS into budget prioritization processes

A think piece series on investing in nature for resilient cities, created in partnership by ICLEI and The Nature Conservancy, makes the case for investing in nature-based solutions and explore mechanisms to leverage the funding and political will for such investments. The series argues that by investing in nature now, we stand to build a better world for cities and nature tomorrow. In the think piece on "*The Coming Rise of Urban Infrastructure - Turning Infrastructure Green*", Andrew M. Deutz of TNC highlights the dual challenge of the need to more than double the amount of urban built infrastructure in the world over the next few decades to meet urbanization and population growth; and financing these growing infrastructure needs. The scale of this challenge is enormous: "G20's global growth targets call for a global infrastructure growth program of some 80 to 90 trillion dollars to meet the United Nations Sustainable Development Goals by 2030, or roughly 6 trillion dollars per year. Seventy percent of global infrastructure demand in the next 15 years will come from cities, mainly in the developing world". In a post-Covid-19 world, the financing situation is exacerbated as nations, economies, governments and societies face the challenge of addressing the economic repercussions of lockdown and rebuilding communities.

Cities are mandated to provide services and infrastructure to local communities and will be at the coalface of addressing these challenges. In the developing world the situation is magnified by backlogs and funding challenges. In a rapidly urbanizing world, city governments and the natural

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resources that sustain life and provide benefits for people are under pressure to meet increased demand for infrastructure, land, water, food etc. The increasing demands strain the financial resources of cities. At the local level, budgets and policies for addressing development and infrastructure challenges are determined by a complex mix of growth and development priorities, fiscal systems, legal mandates, institutional factors and political will. Financing for infrastructure development and service delivery in local governments relies largely on intergovernmental transfer payments, grants, subsidies, taxes and other sources that are unsustainable in the long run.

Despite increasing and active promotion of investing in more sustainable infrastructure solutions, and specifically in nature-based solutions, investment in green-blue infrastructure and ecosystem-based adaptation remains low and even completely out of reach for many cities. The reasons are complex: In certain parts of the world, the capacity of city governments to secure additional external funds is often hampered by a lack of capacity and limited access to external funding due to poor credit ratings. Another reason is the lack of "bankable" projects. Cities' appetites for venturing outside of their normal revenue streams and fiscal allocations, with associated budgeting and reporting processes and cycles, remain relatively low. Supported by traditional public service planning frameworks and a "business as usual" outlook, government officials are often not expected nor encouraged or equipped to create attractive, innovative, profitable and sustainable business propositions which would draw new public and private investors to the table. Traditionally, the focus is more on day-to-day basic service delivery and maintenance than to test, transform, disrupt and co-create innovative projects that would redefine our cityscapes and systems. And in some countries, public finance policy and regulatory requirements also contribute to low external investment at city level.

However, this is changing. Cities are increasingly realizing that a thriving natural environment of green corridors, healthy ecosystems, ample and safe green open spaces, food gardens, green and blue infrastructure and daily community engagement with nature, enhances resilience and the quality of life and health and well-being of urban communities. The health and social impacts of the Covid-19 pandemic has driven this lesson home hard. Global leaders, the UN and nations are rallying to the call to "build back better" after Covid-19. Linked to this call, and the global discourse around a new deal for nature and people to bend the curve in biodiversity loss, is a call for a new social contract for nature.

A key part of 'building back better' and bending the biodiversity loss curve, will be to shift infrastructure investment and financing priorities at the local level. Fiscal policy lies at the heart of creating an enabling environment for embracing sustainability, and nature-based solutions in particular. This is integral to addressing the multiple challenges associated with rapid urbanization. Cities, especially fast-growing urban nodes in Asia and Africa, urgently need to rethink the way in which they approach, plan and prioritize budgets. City governments need to *work with*

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nature – rather than against it – when planning and building cities. In order to make this shift towards working with nature and adopting nature-based solutions, the very principles that underpin planning, budgeting and fiscal policy need to be reviewed or, in many instances, completely turned around.

The Cost of Inaction in Loss of Ecosystem Goods and Services

Land use change is a major driver and threat to biodiversity and the distribution of ecosystem services.[19] The growth of the human population and the subsequent expansion of urban areas is resulting in significant land use changes. Urbanization is therefore influencing the supply and use of ecosystem services, as well as the distribution of these services to potential beneficiaries.[20] Furthermore, the increasing number and size of cities and urban populations may result in shortages of ecosystem goods and services. For example, Güneralp et al., (2013) state that urbanization will have an impact on the availability of freshwater.[21] The growth of urban areas will result in the growing demand for natural resources, many of which are not found within the city environment but are sourced from elsewhere.

In 2005 the Millennium Ecosystem Assessment (MEA) estimated that approximately 60 percent of ecosystem services are degraded and used unsustainably, creating adverse effects on human health and well-being.[22] Therefore, if ecosystems are not effectively and sustainably managed and restored, the consequences will be costly to a range of sectors and will ultimately affect urban communities the most. In addition, the failure to address many of the biodiversity challenges will undermine the ability to achieve other global objectives, such as climate change mitigation and food and water security.[23]

One of the major challenges is that biodiversity and ecosystem services are undervalued. Predominantly due to the lack of knowledge and understanding between economies and ecosystems. In addition, the majority of ecosystem services are not priced in the market because they are considered public goods. Several assessments and initiatives, such as the Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) have tried to derive the economic value of biodiversity and the services it delivers. It is estimated that more than half the global GDP depends on biodiversity

[19] IPBES (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services.

[20] Eigenbrod, F., Bell, V.A., Davies, H.N., Heinemeyer, A., Armsworth, P.R., and Gaston, K.J. (2011) The impact of projected increases in urbanization on ecosystem services. Proceedings of the Royal Society B: Biological Sciences. 278 (1722), 3201–3208. doi:10.1098/rspb.2010.2754

[21] Güneralp, B., Mcdonald, R.I., Fragkias, M., Goodness, J., Marcotullio, P.J. and Seto, K.C. (2013) Urbanization Forecasts, Effects on Land Use, Biodiversity, and Ecosystem Services. In: Thomas Elmqvist, Michail Fragkias, Julie Goodness, Burak Güneralp, et al. (eds.). Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. p. 771. doi:10.1007/978-94-007-7088-1_22.

[22] Millennium Ecosystem Assessment. 2005. Millennium Ecosystem Assessment Synthesis Report. Island Press, Washington, D.C.

[23] OECD (2019) Biodiversity: Finance and the Economic and Business Case for Action (report prepared for the G7 Environment Ministers' Meeting, 5-6 May 2019). doi:10.1787/a3147942-en.

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and the services which it delivers.[24] Though there is some degree of uncertainty associated with many of the economic valuations, they effectively demonstrate that the failure to address biodiversity loss and ecosystem degradation is and will continue to be costly. [25]

The loss of biodiversity is not only decreasing the supply of ecosystem services, but the distribution and equity of benefits. Through assessments, such as TEEB and MEA, the socio-economic benefits of biodiversity have also been highlighted.

The G20 member countries can realize multiple financial savings in the long run, by ensuring sustainable use and benefit sharing of ecosystem services and the sustainable flow of nature's benefits to people. One mechanism is to ensure that there are sufficient economic incentives to conserve and sustainably use biodiversity. For example, payment for ecosystem services (PES) or Reducing Emissions from Deforestation and Forest Degradation (REDD+) are some of the advances in the innovations of nature-based solutions for ecosystem restoration and management of ecosystem goods and services that have been made. Not only do these approaches ensure that provisioning benefits of the ecosystem goods and services are secure, but also provide benefits for people.

The socio-economic costs of inaction to biodiversity loss and ecosystem degradation are massive and is currently one of the biggest threats to humanity. For example the loss of biodiversity will result in reduced crop yields and fish catches, increased economic loss from flooding and other disasters, and the loss of potential new sources of medicine. It is therefore critical to understand the value of biodiversity so that it can be integrated into policy and decision-making processes at local, regional, national and global scales.

Case from Riyadh - Wadi Hanifah

In the preparatory needs assessment stage of the Wadi Hanifah valley restoration, the city assessed that the consequences of taking no action would result in the continued deterioration of Wadi Hanifah and the persistence or escalation of problems. These consequences, such as poor water quality and related health concerns, loss of opportunity to use recycled water for both the growing city and agriculture demand, consequent yet greater reliance on costly water supplies from desalination plants, and difficulty in reducing flood damage, spurred the city authorities to act.

[24] European Union (2020), Factsheet: The business case for biodiversity - The European Green Deal, European Commission, Brussels
Factsheet: Economic impact of biodiversity

[25] OECD (2019) Biodiversity: Finance and the Economic and Business Case for Action

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Ecosystems as Economic Assets and Lower-Cost Solutions to Multiple Challenges

Most cities "import" ecosystem goods and services[27] and the resulting loss of these services is having both a social and economic impact[28]. With rapid urbanization, there is a growing concern around how to ensure the continued flow of these services to urban areas, without threatening the ecological stock.[29] It is often assumed that ecosystems will provide a healthy flow of goods and services without management or specific intervention.[30]

This is predominantly due to the fact that the full extent of the economic benefits of nature are poorly understood, as these benefits are often not quantified. For example, benefits such as carbon sequestration or recreational value cannot be monetized and are often not accounted for as a benefit from nature.[31] Unlike investments which yield high returns, natural asset investments are often perceived to not generate sufficient returns.[32] Most of the ecosystem goods and services provided by nature are not captured in conventional economic indicators, such as GDP.[33] The value of these assets is therefore, generally not included in financial decision-making processes at the local level. These decisions can often have an impact on budget allocations for departments that manage natural assets and the subsequent flow of ecosystem goods and services.

The benefits of protecting natural systems, in certain contexts, outweigh the costs.[34] There is growing evidence that nature-based solutions have the potential to address multiple urban challenges and can be more cost-effective in the long run, than engineered alternatives. Nature-based solutions can address both mitigation and adaptation challenges that deliver multiple benefits for both nature and people, particularly in more vulnerable sectors of society. For example, planting trees and increasing green spaces in urban areas can help with urban cooling, while also sequestering carbon, reducing air pollution, creating recreational space and providing health benefits for urban residents. In contrast, hard engineering solutions seldom provide additional benefits beyond the single function for which it was built.[35]

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[27] De Wit, M., Van Zyl, H., Crookes, D., Blignaut, J., Jayiya, T., Goiset, V. and Mahumani, B.,. (2012) Including the economic value of well-functioning urban ecosystems in financial decisions: Evidence from a process in Cape Town. Ecosystem Services. 2, 38–44. doi:10.1016/j.ecoser.2012.08.002

[28] Sukhdev, P. (2011) Putting a Price on Nature: The Economics of Ecosystems and Biodiversity. Solutions. 1 (6), 34–43. http://www.thesolutionsjournal.com/print/823

[29] See note 27

[30] Ibid

[31] Seddon, N., Chausson, A., Berry, P., Giradin, C., Smith, A., and Turner, B., (2020) Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions The Royal Society. 375: 20190120. doi:10.1098/rstb.2019.0120

[32] Ibid; See note 26

[33] See note 28

[34] Sukhdev, P. (2011) Putting a Price on Nature: The Economics of Ecosystems and Biodiversity; Seddon, N. et. al.., (2020) Understanding the value and limits of nature-based solutions to climate change and other global challenges

[35] Jones, H.P., Hole, D.G. & Zavaleta, E.S. (2012) Harnessing nature to help people adapt to climate change. Nature Climate Change. 2, 504–509. doi:10.1038/nclimate1463

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Sukhdev (2011) states that climate change mitigation or ecosystem adaptation cannot and should not be solely addressed by engineered or man-made infrastructure solutions. In some cases, natural systems or nature-based solutions can provide more efficient solutions and offer key advantages, than engineered infrastructure. Depending on the challenges being addressed, it is, however, important to consider finding synergies between nature-based solutions and man-made or engineered infrastructure, particularly in cities.

The 2020 World Economic Forum Global Risks Report recognizes the economic risks posed by biodiversity loss, natural disasters and climate action failure, whilst emphasizing the need for more nature focused solutions. Indeed, this report ranks biodiversity loss, which has critical implications for humanity, from the collapse of food and health systems to the disruption of entire supply chains, as the second most impactful and third most likely risk for the next decade. The loss of ecosystem services will, and is already having, significant social and economic costs. Urban areas are particularly exposed to these threats, as they are generally the centers for economic activity.

It must be recognized that natural resources and ecosystems services influence economic performance over the long-term and should therefore be considered public goods or natural economic assets. If nature contributes to the economy, then similar to other economic assets, natural assets need to be managed effectively and sustainably.[39] Valuing ecosystem services is not necessarily commodifying them for trade in markets, but is a means to provide helpful information in sustainably and effectively managing these natural assets.[40] Furthermore, investment in the protection of ecosystems services, using nature-based solutions for restoration or conservation efforts, can augment other economic activities, such as agricultural sustainability or improved supply of freshwater. Nature-based solutions are therefore a way to reconcile economic development and diversify and transform business to enable sustainable development.

Case of Rio Verde Novo, Reforestation Program

The poorest and most vulnerable population of Rio de Janeiro City, Brazil, has been pushed to live on depreciated areas of the slopes of the Atlantic Forest hills or by the rivers in mangrove swamp regions. The disorderly and irregular occupation after deforestation, together with the improper waste disposal and growth of urbanization, Considering that the inhabitants of informal settlements are the

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[36] Sukhdev, P. (2011) Putting a Price on Nature: The Economics of Ecosystems and Biodiversity.

[37] Costanza, R. (2006) Nature: ecosystems without commodifying them. Nature. 443, 749–749.

[38] World Economic Forum (2020) The Global Risks Report 2020, 15th Edition.

[39] See note 37

[40] Costanza, R. (2006) Nature: ecosystems without commodifying them

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Case of Rio Verde Novo, Reforestation Program

most affected by the landslides, in 1986 Rio de Janeiro City Hall organized a reforestation task force focused on recovering the slope of the Atlantic Forest, using the labor of the local communities. These activities expanded to mangrove areas, and currently the program has two seed collection teams and six nurseries with a maximum production capacity of more than one million seedlings per year.

Over the past 33 years, ten million seedlings were planted by the initiative, covering an area of approximately 3 hectares, spread across 92 neighborhoods, having trained 15,000 workers from vulnerable communities, who went through the work experience in the task force. Nowadays, this program is called Reforest Rio and includes the ***Rio Verde Novo*** project, which contemplates areas where it is not possible to act with the community labor and the Reforestation Task Force Program.

The criteria used for selecting areas assisted by the Reforestation Task Force are the presence of low-income communities in the immediate surroundings, organized in associations of residents; the presence of deforested slope areas; basins hydrographic areas subject to flooding; the presence of permanent environment preservation areas with strong irregular occupation pressure; the occurrence of deforested areas inside and around Conservation Units.

The socioenvironmental services provided by the reforestation of urban forests are very relevant. Among them, it is possible to list the sequestration of CO2, regulation of the microclimate, improvement of the air quality, provision of shelter and food for the fauna, reduction of soil erosion, reduction of the silting up of rivers and watercourses. In addition to those that directly impact the daily lives of vulnerable communities, such as the delayed flow of intense rains, reducing the risk of floods, and the containment of unstable slopes. In addition to the increase in biodiversity and environmental gains resulting from the preservation of urban forests, the program expands the city's resilience capacity, reducing the risk of floods, soil erosion, and landslides It is important to highlight that the municipality of Rio spends around 100 million dollars in flood prevention annually.

Likewise, the reforestation task force is an important source of income for vulnerable families involved in the program. The initiative also provides professional training and environmental awareness as a source of empowerment for the community. The majority of the task force workers are between 18 and 58 years old. Despite the fact that the program offers a type of paid voluntary job to members of the communities, as the assisted population suffers difficulties to get a formal job, the selected participants remain in the program for most of their lives. Half of the workers integrate the program for over 10 years and the income generated by reforestation is the only source of income for sixty percent of households.

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Existing Measures to Improve Investment in Urban Resilience

While the financing of nature-based solutions by cities remains a challenge, the multiple challenges associated with rapid urbanization have led to a growing realization that innovative finance options, which support nature-based solutions, are imperative to improving sustainability and resilience. City governments need to compare the full long-term cost of "free" ecosystem services that are healthy and well-maintained with the cost of the loss of hard/conventional engineering solutions. In addition, cities need to think differently about where to seek the best return on investment, as significant additional financing is required to ensure urban resilience, particularly in the developing world.

Greening fiscal policy opens the door for innovative fiscal reforms that can introduce new revenue streams for nature-based solutions. For example, cities can introduce tax incentives, 'green' taxes and tailored financial programs to promote the application of nature-based solutions to address infrastructure and service provision challenges. Multilateral development finance institutions, such as The World Bank, can also contribute towards resilience investments that enable upscaling of smaller interventions. These investments assist not only in addressing some of the financial, technical and capacity challenges experienced at a local level, but can also mobilise much-needed private sector investments.[41] The International Finance Corporation (IFC) showed that for every dollar invested by multilateral finance institutions in climate related initiatives, three dollars was leveraged from private sector finance.[42]

A paradigm shift from the dependency on conventional quick-fix options to nature-based solutions such as green and blue infrastructures is needed. Cities should identify the direct and indirect contributions of nature-based solutions, such as the economic value of ecosystem services, and mainstream this into policy and decision-making on infrastructure investment and development to ensure urban resilience.

Case of the uMngeni Ecological Infrastructure Partnership

Cities can also expand the available funding envelope by sharing the financial burden through collaboration and adopting nature-based solutions. One such example is the uMngeni Ecological Infrastructure Partnership, which aims to address the deterioration of the uMngeni catchment. The catchment is the primary source of freshwater supply for the cities of Pietermaritzburg and Durban, which are key economic centers in the province of KwaZulu-Natal. The partnership was born from

(continued)

[41] For example, air pollution is Beijing's greatest environmental problem. The air purification and temperature regulating services of forest ecosystems surrounding Beijing have been valued at around 1.03 billion euro annually (based primarily on avoided air pollution charges and electricity savings). Faced with the challenge of deteriorating air quality, the local Beijing government initiated a program in 2012 to invest around US$4.7 billion in planting 67 000 hectares of trees around Beijing over the next few years.

[42] SANBI and Wildlands Conservation Trust. 2015. Case study: Local government and civil society: uMngeni Ecological Infrastructure Partnership. Compiled by Botts, E.A. for the South African National Biodiversity Institute, Pretoria

Challenges and Opportunities

Case of the uMngeni Ecological Infrastructure Partnership

discussions between the South African National Biodiversity Institute and leadership at eThekwini Municipality, when realization that engineering solutions were too costly and not able to solve the problem of providing clean potable water single handedly.[43] Furthermore, the solution required collaboration between multiple actors to secure green infrastructure investments and improve water security in the greater uMgeni catchment.

The wide range of public and private partners that are interested and working within the uMngeni catchment, enabled the support for the partnership to be solicited. There are over 21 parties that are signatories to the memorandum of understanding (MoU), which include eThekwini Metropolitan Municipality (Durban), neighboring local authorities, including Msunduzi Local Municipality (Pietermaritzburg) and uMgungundlovu District Municipality, as well as other South African provincial- and national authorities, civil society organizations, academia, and major industry and business sector associations. With leadership from the 3 municipalities, three ecological infrastructure pilot projects have been undertaken to demonstrate the proof of concept. These initiatives have enabled effective communication on the importance of ecological infrastructure and functioning natural ecosystems to address municipal concerns and priorities.[44]

4. Innovative Biotechnologies to Maximize Quality of Urban Ecosystems

Biotechnology and its relevance to urban resilience

Biotechnology is a broad term used for technologies with application of biological processes. This ranges from plant breeding to employment of bacteria for waste treatment, from the fermentation of cheese to the development of biofuels as renewable energies. Modern biotechnology refers to technologies employed at the molecular level, such as cell cultures and manipulations, genome studies and genetic engineering. These scientific discoveries and technological advances have allowed immense improvements and developments of healthcare, agriculture, and industrial sectors. In the context of nature-based solutions to increase resilience, biotechnology has demonstrated successful applications in crop management, ecosystem restoration, and combating disease. Opportunities in other areas, such as the mitigation of threats to forest health, have been identified but not yet fully understood for safe usage and scaled-up deployment.

Biotechnology can help crops and plants adapt better to increased levels of environmental stress and with changing climates, it can thus significantly contribute to the protection of food security. The development of agriculture and gardening over millennia has been based on biotechnology, with the first selection of

[43] Ibid.

[44] Clements, R., J. Haggar, A. Quezada, and J. Torres (2011). Technologies for Climate Change Adaptation – Agriculture Sector. X. Zhu (Ed.). UNEP Risø Centre, Roskilde, 2011.

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wild seeds to breed taller, more productive, or specific colors of plants allowing humans to nurture desired traits. Modern biotechnology has taken this from the fields to research labs, where genetic studies have allowed us to screen genetic material for the presence of desired traits, suppress gene expression to improve drought resistance or vitamin production, or even transfer favorable genes and alleles from one species to another. Although controversial in nature, the greatest impact of biotechnology demonstrated on agriculture thus far has been the development of pest and disease-resistant plants. A common use of biotechnology is to speed up the traditional breeding process. As the presence of desired traits are not always easy to identify and separate with the naked eye, by identifying the genes linked to traits such as natural pest resistance and productivity, they can be effectively combined through breeding.[45] Some co-benefits resulting from the use of biotechnology are the decreased use of pesticides and chemicals, mitigation of CO_2 emissions, and saving of land-use from increased productivity.

Biotechnology can contribute to the restoration of degraded land ecosystems and to protect pollution from entering our oceans, integral parts of SDG 15 Life On Land and SDG 14 Life Below Water. In urban contexts, individual trees and forests are often considered separately; however, it is important to consider holistic landscapes. Such an approach integrates urban forests, soil quality, biodiversity, water supply, and land-use considerations for restoration of ecosystems.[46] With biotechnology interventions, bioremediation processes can help address pollution, microbiomes essential for nutrients and water cycles can be restored, and microorganisms can act as biofertilizers to improve soil quality. For contaminated water bodies, deployment of floating structures as “wetlands” with plant species capable of extracting heavy metals, toxins, or excess nutrients can mitigate pollution.[46] On the microbial level, biotechnology has long been applied in wastewater treatment and potable water treatment by using bacteria to break down, separate and collect waste, and remove chemical contaminants through processes such as activated sludge, trickling filters, or anaerobic treatment[47]. Manipulations of soil microbiomes to enhance restoration can also be implemented by introducing a mix of microorganisms in a microbial consortium. With stimulants to activate the microbiota, nutrient cycling is enhanced and in turn encourages further microbial activity and soil fertility. Bacteria, such as cyanobacteria, which are highly resistant to dry conditions and contribute to soil fertility and prevention of soil erosion also have the possibility to be engineered to prevent desertification and accelerate the restoration of degraded drylands.[48]

In combating diseases, developments in biotechnology have greatly contributed to improving the resilience of human life and can continue to have large impacts, especially on vulnerable populations in cities. The development of antibiotics, vaccines, and antibody drugs were

[45] FAO 2015

[46] Arup 2020

[47] Büyükgüngör, Hanife & Gürel, Levent. (2009). The role of biotechnology on the treatment of wastes. AFRICAN JOURNAL OF BIOTECHNOLOGY. 8. 7253-7262. 10.4314/ajb.v8i25..

[48] Maestre, Fernando & Sole, Ricard & Singh, Brajesh. (2017). Microbial biotechnology as a tool to restore degraded drylands. Microbial Biotechnology. 10. 10.1111/1751-7915.12832.

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made possible with the understanding of the molecular biology of bacteria and viruses and the development of mechanisms to target them. Antibiotics target the reproduction of bacteria or break down their cell components. Vaccines are weakened versions, inactivated, or parts of bacteria or viruses that trigger the human immune system to develop antibodies to fight future occurrences. With the COVID-19 pandemic ongoing, the successful performance of such research is now crucial to protect lives, ensure public health in crowded cities, and recover economies.

Along with the many opportunities, there are concerns with the use of some biotechnology that remain to be addressed. In agriculture, loss of biodiversity has been observed in crops such as maize, soybean, and cotton, and climate-resistant seeds for crops are only reaching a small percentage of smallholder farmers.[49] In natural ecosystems, the secondary effects and implications of introducing new genotypes are unclear--they may be potentially invasive, trigger environmental responses, or have effects through the food chain. Greater understanding of complex genetic traits is needed, along with an understanding of their interactions in diverse ecosystems. In addition, economic and social impacts need to be explored and understood, in order to design effective regulations and frameworks for intellectual property rights, indigenous knowledge, and bioprospecting.[50]

Creating Enabling Conditions for Local Innovation

Cities have the opportunity to create enabling conditions for local development, experimentation, and implementation of innovative biotechnology for the resilience of urban ecosystems. As illustrated, biotechnology is increasingly important in maximizing the quality of urban ecosystems. Yet, many cities are not using biotechnology to its full potential in ensuring ecosystem quality. In the same way that clustering has supported technological innovation in cities and that certain factors influence innovation in urban applications of nature-based solutions, cities can create conditions for innovation hubs and ecosystems around environmental biotechnology for resilience applications.

There are cities and countries that have managed to create such hubs for specific kinds of biotechnology, such as for pharmaceuticals or seed development companies, and many learnings can be applied. The clustering of innovation has been observed and even created in certain regions and cities. Although some iconic clusters for innovation, like the Silicon Valley, saw the co-development of both technology and institutions together, there are also policy-induced pharmaceutical biotechnology clusters in the eastern coast of China, in Beijing, Shanghai, and Shenzhen.[51] Such clusters are key to translate science into commercial ventures, due to the

[49] Access to Seeds Index 2019. Global Seed Companies. <https://www.accesstoseeds.org/index/global-seed-companies

[50] Krishna R. Dronamraju "Emerging Consequences of Biotechnology: Biodiversity Loss and IPR Issues"

[51] Ong, Serene. 2008. "Biotechnology Parks: China into the Next Future". Asia-Pacific Biotech News. Volume 12, Number 14. <https://www.asiabiotech.com/15/1503/0034_0039.pdf>

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ecosystem of stakeholders necessary. Academics and entrepreneurs, venture capitals and specialists in intellectual property rights, are but a few, Finally the key role of the public sector to structure regulatory environments for innovation must not be forgotten. As an example, in the development and sale of seeds for agriculture, impacts have been observed on the accessibility of seeds when comparing different regulatory environments for competition and pricing.[52]

To expand the scope across sectors, and truly create a city that thrives as an economy based on creating and promoting resilient ecosystems through nature-based solutions of biotechnology innovation, soft factors that influence innovation in urban applications of nature-based solutions must also be considered. According to the EU Horizon 2020 Naturvation project, factors influencing innovation in urban applications of nature-based solutions include cognitive ones such as awareness, uncertainties in decision making, and sense of urgency, as well as agency factors such as leadership and commitment. By creating public discourse and setting future visions of the city, such as through strategic plans and regulations, city authorities can signal to innovators that there is long-term commitment and support for innovation.

5. Reporting and Measuring of Efforts

Managing Ecosystems

Healthy and well managed ecosystems can deliver a number of benefits to cities and urban society. Such benefits, emanating from a full spectrum of urban nature, are called ecosystem services. They support directly or indirectly our survival and quality of life and can be grouped as provisioning, regulating, supporting or cultural services. Urban quality of life and sustainability depend on functioning and healthy ecosystem services to provide and support water and air purification, climate regulation, flood attenuation etc. It is, therefore, important to enhance, restore, manage and sustain ecosystems to ensure the continued supply of their services to urban citizens and to improve urban resilience. The importance and value of these ecosystem services should entice local governments and policy makers to safeguard these functions and the natural ecosystems in the city.

In order to understand the value of ecosystems and manage them, ecosystem assessments and valuations are necessary.

It is difficult for cities to manage their ecosystems appropriately when their value is poorly understood. Measuring the full extent to which ecosystems improve urban resilience is critical in making the case for their appropriate management and restoration. An example of such an assessment tool is The Economics of Ecosystems and Biodiversity (TEEB), which provides a structured approach with considerations for policy-makers to assess and recognize the benefits of ecosystems and biodiversity, demonstrate their value in economic terms, and ensure value is captured by assessing policy options and their impacts. More information on valuation methodologies for better decision-

[52] Clements, R., J. Haggar, A. Quezada, and J. Torres (2011). Technologies for Climate Change Adaptation – Agriculture Sector. X. Zhu (Ed.). UNEP Risø Centre, Roskilde, 2011.

[53] Van der Jagt, Alexander, 2017. "The Nature of Innovation for Urban Sustainability". <https://naturvation.eu/sites/default/files/news/files/naturvation_the_nature_of_innovation_for_urban_sustainability.pdf>

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making can be found in the whitepaper “Urban health, safety, and well-being: cities enabling the provision and access of ecosystem services” of this U20 taskforce.

To understand overall resilience and sustainability of the city, existing city resilience guidelines and standards can help act as a checklist and self-assessment. Examples of such are the Making Cities Resilient initiative based on the Sendai Framework, and the ISO 37123 standard with indicators for resilient cities. Combined with the City Biodiversity Index developed by Singapore, an index based on urban biodiversity, ecosystem services, and governance, an illustration of a city’s natural assets for resilience and preparedness can be drawn.

In implementing these frameworks for assessment, a challenge often faced by cities is collection, in availability and access, of data. For accurate assessments, data should be verified and up to date. This brings to light the importance of monitoring, the capacity of staff across institutional entities for it, and the governance mechanisms for collaboration with stakeholders in different sectors of the city.

Case Study: Ecosystem Services Assessment in Johannesburg

The City of Johannesburg (CoJ) in South Africa is undertaking a high level and strategic Ecosystem Services Assessment for the municipal area. The objective of conducting a high level and strategic Ecosystem Services Assessment is to provide the City with new information about the importance of Johannesburg’s urban nature, on the well-being of its citizens and the relative economic costs and savings associated with investment in urban nature. The assessment will be used to build an understanding within city governance of the benefits and economic and social value of these ecosystems and make the case for investment opportunities and bankable projects. Overall, this will facilitate the mainstreaming of ecosystem services perspectives into the City’s land use, spatial and development policy frameworks and decision-making processes. Furthermore, this will provide the foundation for building a sustainable investment case for planning, working and developing with nature in the city.

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Case Study: Singapore Cities Biodiversity Index

Due to the lack of biodiversity indicators for assessment at the local level, Singapore proposed and developed the Cities Biodiversity Index in 2008. This self-assessment tool for cities is composed of a qualitative background profile of the city, together with a quantitative scoring of 23 indicators. These indicators score the change in native biodiversity, provision of ecosystem services, and presence of governance mechanisms for biodiversity, with a maximum score of 4 for each indicator. Examples of indicators include the proportion of natural and protected areas, change in number of bird and plant species, regulation of quantity of water, formal educational visits of children to parks, budget allocation for biodiversity, and number of biodiversity related jobs.[54]

Cities around the world, such as London, Durban, Montréal, Los Angeles, and Hyderabad, have applied the Singapore Index[55]. From the process, cities have shared that the process built their capacity in biodiversity conservation, the indicators served as guidelines for conservation, and the quantitative scoring helped set their priorities for budget allocation and action.

Sharing and Replicating Lessons Learned and Best Practices

There is a multitude of research, case examples and practical approaches documented in cities as best practice for nature-based solutions. In order to mainstream nature-based solutions quickly across the globe and prevent cities from 'reinventing the wheel', cities need to effectively and efficiently exchange knowledge and transfer solutions with their peers. Trans-municipal learning and collaboratively developing or improving nature-based solutions is the best way to save time, resources, funds and efforts and is particularly necessary in critical areas such as improving urban resilience and protecting biodiversity in cities. Reporting, measuring and evaluating best practices is equally important in order to make practical knowledge and experiences widely available and accessible.

The biggest challenge to trans-municipal cooperation and reporting initiatives is usually the perception of a lack of capacity on the local level or a lack of awareness of existing knowledge exchange infrastructures to facilitate such cooperation. Cities must prioritize their own local action and often feel unable to engage with their peers, even for their own benefit. Overcoming this barrier requires increased awareness of existing, efficient global cooperation platforms and ensuring that cities have the capacity to report their actions adequately. One such platform for biodiversity reporting is CitiesWithNature, which is endorsed by the Secretariat of the Convention on Biodiversity as the reporting platform for local governments. Through the CitiesWithNature Registry, cities can make their experiences accessible as resources to other cities and demonstrate to national leaders the actions being taken.

[54] User's Manual on the Singapore Index on Cities' Biodiversity. https://www.cbd.int/doc/meetings/city/subws-2014-01/other/subws-2014-01-singapore-index-manual-en.pdf

Lessons can also be learned from global programs such as 100 Resilient Cities, where additional capacity was given to local governments in the form of dedicated city staff focusing on resilience as a key topic. This ensured both that cities had the additional capacity to go beyond local action and engage in cooperation and knowledge exchange activities. Additionally, having dedicated senior staff explicitly focusing on resilience increases the awareness of the city of knowledge resources and cooperation platforms available for local governments to engage in.

Case of Montréal With CitiesWithNature

"The City of Montréal has developed six briefing sheets on an equal number of concrete biodiversity initiatives: ecosystems management in large parks, conservation of wildlife trees, renewed and improved wildlife observatories, urban wildlife passages, environmental action days and coexistence with coyotes.

Each sheet describes one initiative that promotes biodiversity, provides advice to help replicate the initiative in other cities, and specifies which 2030 action targets from the Zero Draft of the Post-2020 Global Biodiversity Framework are addressed by the initiative. These briefing sheets were launched on the occasion of World Environment Day 2020. They are intended to contribute to the exchange of expertise between cities and the development of a community of practice at the local level, and in this way, to inspire urban communities to action and accelerate the international movement to create green cities all over the world.

This project was carried out in collaboration with ICLEI-Cities Biodiversity Center, CitiesWithNature and the Secretariat of the Convention on Biological Diversity. It also contributes to several Aichi Targets and to the United Nations' Sustainable Development Goals, in particular Goal 11 (Sustainable Cities and Communities) and Goal 15 (Life On Land)." - Good Practices in Biodiversity: Taking Action to Create Cities with Nature, 2020

[55] Chan, Lena. 2019. The Singapore Index on Cities' Biodiversity: Sharing 10 Years of Application by Cities Globally. https://www.thegpsc.org/sites/gpsc/files/partnerdocs/session3_3.city_practice.pdf

[56] 2020. Good Practices in Biodiversity: Taking Action to Create Cities with Nature. <https://www.cbd.int/action-agenda/contributions/action/?action-id=5eeba456395529000178dcbf>

Recommendations

Recommendations

Addressed to G20 National Leaders

1. Recognize the Full Extent of Nature's Benefits

Ecosystem restoration and ecosystem-based adaptation provide nature-based solutions to a range of urban challenges, therefore the G20 member countries should recognize:

- the economic, social, and environmental value and benefits of nature-based solutions;
- the contribution that the protection and improved management of ecosystem services can provide toward achieving commitments and objectives of global agendas and addressing various socio-economic challenges;
- their potential for improving human health and urban resilience in the face of natural disasters, pandemics and extreme events, especially in cities where 70 percent of the world's population is predicted to be living by 2050.

2. Mainstreaming Nature's Benefits

Policy and governance mechanisms should mainstream the full extent of nature's benefits and contributions to people, to optimize the value and benefits of nature-based solutions. To this end, the G20 member countries should:

- establish enabling conditions and regulatory frameworks to ensure that nature-based solutions are mainstreamed in policy, governance, and budgetary frameworks at all levels of government; and specifically, in cities;
- encourage the use of natural capital accounting (NCA) for measuring and tracking over time the contribution of ecosystems and natural resources to social and economic goals, such as water security, food security, resilience and job creation
- align budgets to account for the protection of ecosystems and the services they deliver and improve planning and decision-making related to the management of natural resources;
- integrate nature-based solutions in their NDCs and disaster risk reduction strategies and frameworks; and
- support cities by encouraging multi-stakeholder engagement in adaptation planning across national and subnational levels of government.

4. Towards an Innovative Approach to Resilience

Biotechnologies and ecosystem quality and functioning

The G20 member countries should:

- Invest human and financial resources to fully understand the potentials and risks of biotechnologies, and deploy innovative biotechnologies to maximize urban resilience to extreme events
- Build capacity of cities and practitioners for realistic expectations and accurate applications of biotechnology in fields related to our urban resilience, such as agriculture, remediation, and healthcare

Recommendations

- Encourage investment in diversification of seed development for local use and a national repository with genomic data, taking into consideration environmental conditions, native biodiversity, and social needs for nutrition and urban food security.
- Develop regulatory environments for biotechnology innovation, with competition policies and intellectual property right policies to ensure accessibility and encourage diversity of innovation
- Plan facilitation of swift deployment of technology in crises situations, such as clinical trials, in cities that are the most affected

Monitoring, Reporting, and Sharing

We cannot plan and manage what we cannot measure. Thus, it is critical for the G20 member countries to:

- put systems and measures in place that support all levels of governments, and cities in particular, in measuring, and reporting on, the return on investment in nature-based solutions and the extent to which mainstreaming nature-based solutions contributes to resilience;
- support cities in data collection and accessing up to date verified data and data analysis;
- encourage the exchange of best practice, tools and lessons learned in applying nature-based solutions between cities, to facilitate the upscaling of innovative solutions at national and global scale.

Addressed to key stakeholders including local / sub-national governments / private sector / civil society

1. Recognize the full extent of nature's benefits

Cities should:

- recognize the value and benefits of nature-based solutions, and their potential for improving human health and urban resilience in the face of natural disasters, pandemics and extreme events.

2. Mainstreaming nature's benefits

Cities should:

- adopt an ecosystem and adaptive management approach and integrate nature and nature-based solutions in urban planning and development processes, as well as local climate action plans and disaster risk reduction strategies, to achieve long-term urban resilience;
- involve stakeholders from diverse groups to strengthen the planning and implementation of nature-based solutions across different sectors;

Recommendations

- design and plan development that promotes green corridors and nature-based solutions, protects ecosystems, and secures ample and safe green open spaces where urban communities can reconnect with nature, to enhance resilience, as well as the quality of life, health and well-being of people living in cities.

The private sector should:

- carry out risk informed investments that consider nature-based solutions and engage in business practices that build resilience, prevent ecosystem degradation and biodiversity loss, enhance green recovery from disasters and align with the CBD ecosystem approach principles and the Sendai Framework.

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Appendices

Cariocas Urban Gardens, Rio de Janeiro

Urban agriculture has been identified by FAO (United Nations Food and Agriculture Organization) as a fundamental strategy for food security, social stability and environmental preservation in the major urban centers of the planet. Thus, the urban community gardens are multifunctional nature-based solutions that respond to a wide range of societal and climate-related challenges. They are directly linked to the Sustainable Development Goals of United Nations #2 (focused on achieving food security, improving nutrition and promoting sustainable agriculture), #8 (based on promoting sustained, inclusive and sustainable economic growth) and #11 (directed to make cities and human settlements inclusive, safe, resilient and sustainable).

The Cariocas Urban Gardens was created in 2006 and currently has been established in 43 urban farms: 24 located in municipal schools and 19 in vulnerable communities. It aims at providing access to healthy food in the city's most vulnerable regions, by identifying areas with the potential to hold urban farms and offering local population the inputs and material supplies to develop organic agriculture. It also fosters environmental education as it shows students the importance of agroecology, the process of food production and the need to have a balanced and healthy diet. Moreover, it provides income generation due to the sale of the production surplus through street fairs by those responsible for food production. At last, it increases green open spaces, enhances vegetation cover and prevents building on risk-prone land, contributing to making cities more resilient. In 2019, the program was awarded the Milan Urban Food Policy Pact Prize in the food production category.

The Cariocas Urban Gardens project also responds to the need of cities to seek the best investments based on the direct and indirect contributions of nature-based solutions in social, economic, cultural and climate aspects, considering the economic value of ecosystem services as a comprehensive approach. The initiative produces about 80 tons of food yearly without the use of fertilizers, agrochemicals or pesticides and requires an average investment of USD 185,031 per year. Considering that more than 120,000 inhabitants enjoy the benefits of the project outcomes yearly, it means a cost per person of USD 1.54. In other words, it is a small fraction of investment to achieve a wide range of beneficiaries and savings in health, social assistance and civil protection.

That is the reason why the urban gardens must be seen and planned as an economic, social and climate asset and a low-cost solution capable of offering great return on investment in different levels. One must consider its financial sustainability. The initiative provides training, ultimately a new profession, and a monthly grant-aid to 170 urban farmers involved in the project for them to buy the supplies needed. Half of the food produced is distributed among inhabitants, public schools, and elderly daycare centers. The other half can be sold to generate additional income for the urban farmers and to purchase agriculture supplies, enhancing their own initiative, contributing to increasing social inclusion and improving the vulnerable communities economy. By selling this surplus, they get their main source of income, which gives the initiative its financial sustainability. The grant-aid provided by the City Hall of Rio de Janeiro is just a small support to guarantee they will be able to keep the initiative going.

In order to achieve operational sustainability, policies frameworks have been reviewed. According to the National School Feeding Program, it is mandatory that 30 percent of schools' purchase foodstuffs directly from family farmers and rural family entrepreneurs or their organizations, enhancing their income generation and backing initiatives such as the Cariocas Urban Gardens. Also, the Municipal Policy of Urban Agriculture Support states goals, tools and definitions to be considered in this kind of activity. Thus, there was a mobilization of different stakeholders, on national and municipal levels, to make this kind of initiative really work.

Currently, the project is increasing its scope towards fish farming, that aims to produce 6 tons to be donated to low-income populations in the communities where they are based in order to reinforce the food production menu of the Cariocas Urban Gardens. Therefore, there is plenty of room to grow and different opportunities for investment attraction. One should highlight that in the case of Cariocas Urban Gardens, new public private partnerships could be set. On one hand, the public sector could manage the area's identification in vulnerable communities. On the other hand, the private sector could focus on providing training for those who live in vulnerable communities and need a new professional perspective. Another option, would be for companies to pay the aid-grant needed for the supplies as a corporate responsibility action, understanding their role in achieving the benefits previously mentioned.

Considering the benefits achieved by such a small amount of investment, the urban gardens must be considered as a multi layered low-cost solution to be prioritized in the public management. It must be seen as an economic, social and climate asset as it provides training and creates jobs, increases the level of social inclusion and the access to good food (food safety) as well as enhances fostering environmental education. Therefore, city governments need to make a paradigm shift from the dependency on conventional quick-fix options and may see the Urban Gardens as an excellent functional option.

Rio Verde Novo, Reforestation Program

Rio de Janeiro City, Brazil, has a tropical Atlantic climate and is geographically located between the sea and the mountains, which creates favorable environmental conditions for high rainfall levels that affect the city every year.

Due to historical and social issues, since the beginning of the city, the poorest and most vulnerable population has been pushed to live on depreciated areas of the slopes of the Atlantic Forest hills or by the rivers in mangrove swamp regions. The disorderly and irregular occupation that follows the deforestation of such regions, added to the improper waste disposal and the growth of urbanization, resulted in severe landslides and floods that cause, ultimately, human and material losses.

Considering that the inhabitants of informal settlements are the most affected by the landslides, in 1986 Rio de Janeiro City Hall organized a reforestation task force focused on recovering the slope of the Atlantic Forest, using the labor of the local communities. In 1995, the program's activities expanded to mangrove areas, such as the *Jequiá* river month, which was the first fishing colony in the municipality and is very impacted by the variation of the tide. The task force began to work on restoring the Restinga forest in 2001, when it received a donation of seedlings from a private producer to recover the Reserva Beach area.

Over the past 33 years, ten million seedlings were planted by the initiative, covering an area of approximately 3 hectares, spread across 92 neighborhoods, having trained 15,000 workers from vulnerable communities, who went through the work experience in the task force. Nowadays, this program is called Reforest Rio and includes the ***Rio Verde Novo*** project, which contemplates areas where it is not possible to act with the community labor and the Reforestation Task Force Program.

Currently, the program counts with two seed collection teams and six nurseries with a maximum production capacity of more than one million seedlings per year, where around 200 tree species and 130 shrubs, herbaceous, and creeper species are produced. All projects are monitored by the technical team of the municipality itself, composed of forestry engineers, agronomists, biologists, and administrators who seek the spirit of the first technicians to do the best possible and deliver the forests to the municipality and to the people who live there.

The socio-environmental services provided by the reforestation of urban forests are very relevant. Among them, it is possible to list the sequestration of CO2, regulation of the microclimate, improvement of the air quality, provision of shelter and food for the fauna, reduction of soil erosion, reduction of the silting up of rivers and watercourses. In addition to those that directly impact the daily lives of vulnerable communities, such as the delayed flow of intense rains, reducing the risk of floods, and the containment of unstable slopes. Moreover, the Reforestation Task Force is a source of empowerment and income generation to the supported communities.

The criteria used for selecting areas assisted by the Reforestation Task Force are the presence of low-income communities in the immediate surroundings, organized in associations of residents; the presence of deforested slope areas; basins hydrographic areas subject to flooding; the presence of permanent environment preservation areas with strong irregular occupation pressure; the occurrence of deforested areas inside and around Conservation Units.

The majority of the task force workers are between 18 and 58 years old. Despite the fact that the program offers a type of paid voluntary job to members of the communities, as the assisted population suffers difficulties to get a formal job, the selected participants remain in the program for most of their lives. Half of the workers integrate the program for over 10 years and the income generated by reforestation is the only source of income for sixty percent of households.

The success of the Reforestation Program and its long-term duration is due to engagement between the City Hall and different stakeholders such as social entities, academy representatives, as well as public-private partnerships. In addition to the increase in biodiversity and environmental gains resulting from the preservation of urban forests, the program expands the city's resilience capacity, reducing the risk of floods, soil erosion, and landslides It is important to highlight that the municipality of Rio spends around 100 million dollars in flood prevention annually.

Likewise, the reforestation task force is an important source of income for vulnerable families involved in the program. The initiative also provides professional training and environmental awareness as a source of empowerment for the community.

Case Study: Prevention, Monitoring, and Response to Extreme Weather Events: The Case of the Municipality of Rio de Janeiro, Brazil

Rio de Janeiro City, Brazil, has a tropical Atlantic climate and is geographically located between the sea and the mountains, which creates favorable environmental conditions for high rainfall levels. Together with disorderly and irregular occupation of slopes by vulnerable population, high rate of deforestation, and improper waste disposal, the city has been suffering severe landslides. Ultimately, these events result in human and material losses. For this reason, the city government identified the need to work on prevention, monitoring, and response to extreme weather events.

Heavy rains that fell over the city, in April of 2010, provoking floods, landslides and chaos in traffic became a milestone for the development of such policies. After the above-mentioned weather hazards, Rio de Janeiro City Hall started to build, along with private partners, an operation center, currently called Rio Operations and Resilience Center (COR), with the main purpose of preventing, monitoring and alerting the population on emergencies, in order to reduce the loss of life and material damage.

Rio Operations Center gathers more than 30 public bodies and institutions to monitor daily and continuously the city's operation in favor of responding quickly and efficiently to emergency situations. This center is also responsible to alert the population about risks and urgent measures in case of crisis related to climate changes such as heavy rains and landslides.

From COR, the civil defense can active, as well, direct channels of communication to local residents of 102 communities in imminent risks, such as SMS messages and sirens installed in vulnerable areas. This system triggers the eviction process, when necessary, that is supported by trained community agents.

Although COR's Operation of monitoring and emergency assistance covers the whole population of more than six million inhabitants of Rio de Janeiro City, some specific initiatives must be done towards vulnerable groups, such as kids and youngsters, in order to enhance their capacity to face major natural disasters.

In this regard, the Citizen Security initiative was conceived to increase the safety level in schools during natural disasters by developing emergency plans to be adopted by education professionals and students during this kind of situation. In March 2020, Rio de Janeiro City held the Citizen Security Workshop to discuss these emergency plans with representatives of Rio de Janeiro, Mexico City, Lima,

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Quito, San Juan, Sucre, Brasília, São Paulo and Tegucigalpa and counted on the support of UCCI (Iberoamerican Capital Cities Union). The protocols produced will serve as a model to be adopted by their civil defense bodies, considering their social and economic particularities. Thus, one intends to stimulate behavior changes towards new prevention and civil protection culture for future generations.

As previously mentioned, Rio de Janeiro City has been investing, developing and implementing actions in order to provide its whole population with information about prevention and reaction in cases of natural disasters, while keeping in mind the need to perform specific measures towards vulnerable groups such as kids and youngsters. The above-mentioned prevention actions, along with COR's role in monitoring and quickly answering emergencies resulted in a drastic reduction in the number of occurrences and fatal victims of weather and other incidents, allowing to increase the level of resilience in the city of Rio de Janeiro.

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