U20
RIYADH 2020
URBAN

Urban Health, Safety, and Wellbeing

Cities Enabling the Provision and Access to Ecosystem Services

Nature-based Urban Solutions

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List of Definitions and Acronyms

CBD: Convention on Biological Diversity

CES: Cultural Ecosystem Services

DALY: Disability-Adjusted Life Year

DMOSS: Durban Metropolitan Open Space System

EEA: European Environmental Agency

EMA: eThekwini Municipal Area

EPA: United States Environmental Protection Agency

ES: Ecosystem Services

GAHP: Global Alliance on Health and Pollution

GAM: Greater Amman Municipality

GIS: Geographic information System

IDB: Inter-American Development Bank

IUCN: The International Union for Conservation of Nature

LAC: Latin America and the Caribbean

MEA: Millennium Ecosystem Assessment

MPA: Maputaland-Pondoland-Albany

NDVI: Normalized Difference Vegetation Index

PNV: Potential Natural Value

RES: Recreational Ecosystem Services

SAR: Saudi Riyal

TEEB: The Economics of Ecosystems and Biodiversity

TEV: Total Economic Value

UES: Urban Ecosystem Services

UGS: Urban Green Spaces

UN: United Nations

URBELAC: Urban European and Latin American and Caribbean Cities

USD: U.S. Dollar

WHO: World Health Organization

WTP: Willingness to Pay

WWF: World Wildlife Fund

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

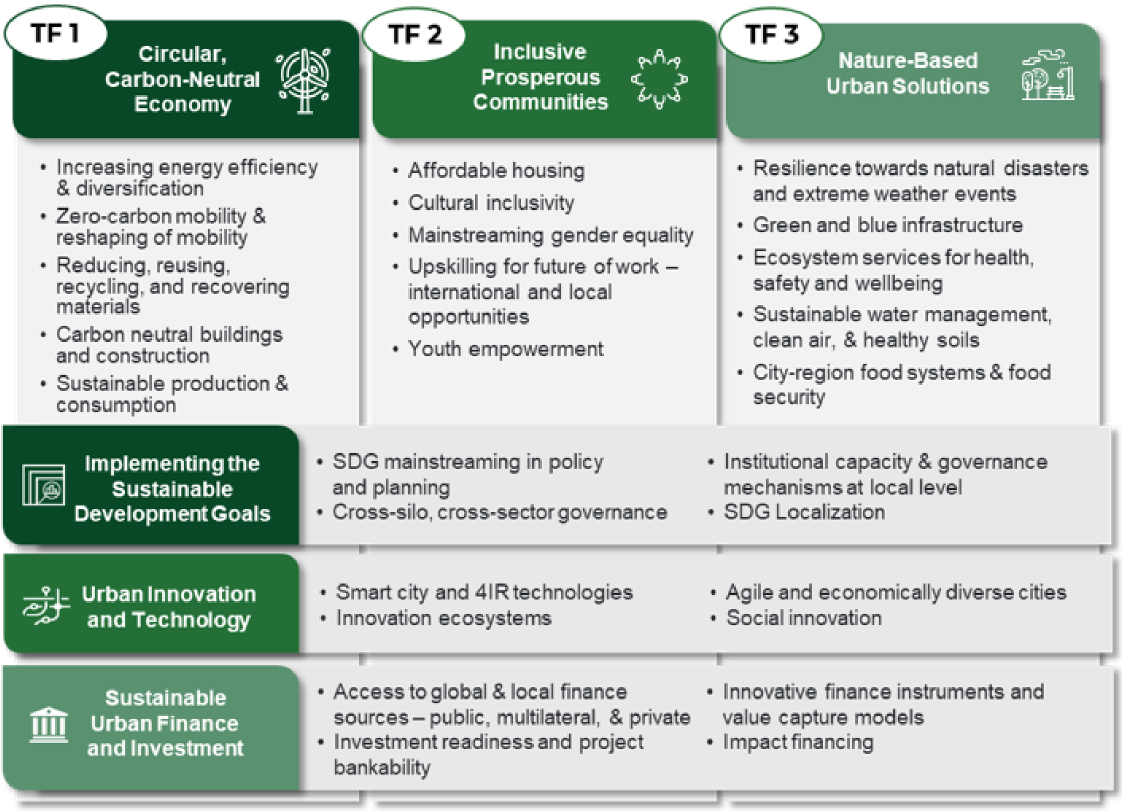
As U20 Chair, Riyadh has introduced taskforces to add additional structure and focus to the U20. These taskforces explore specific priority issues and bring evidence-based solutions to the final Communique.

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:



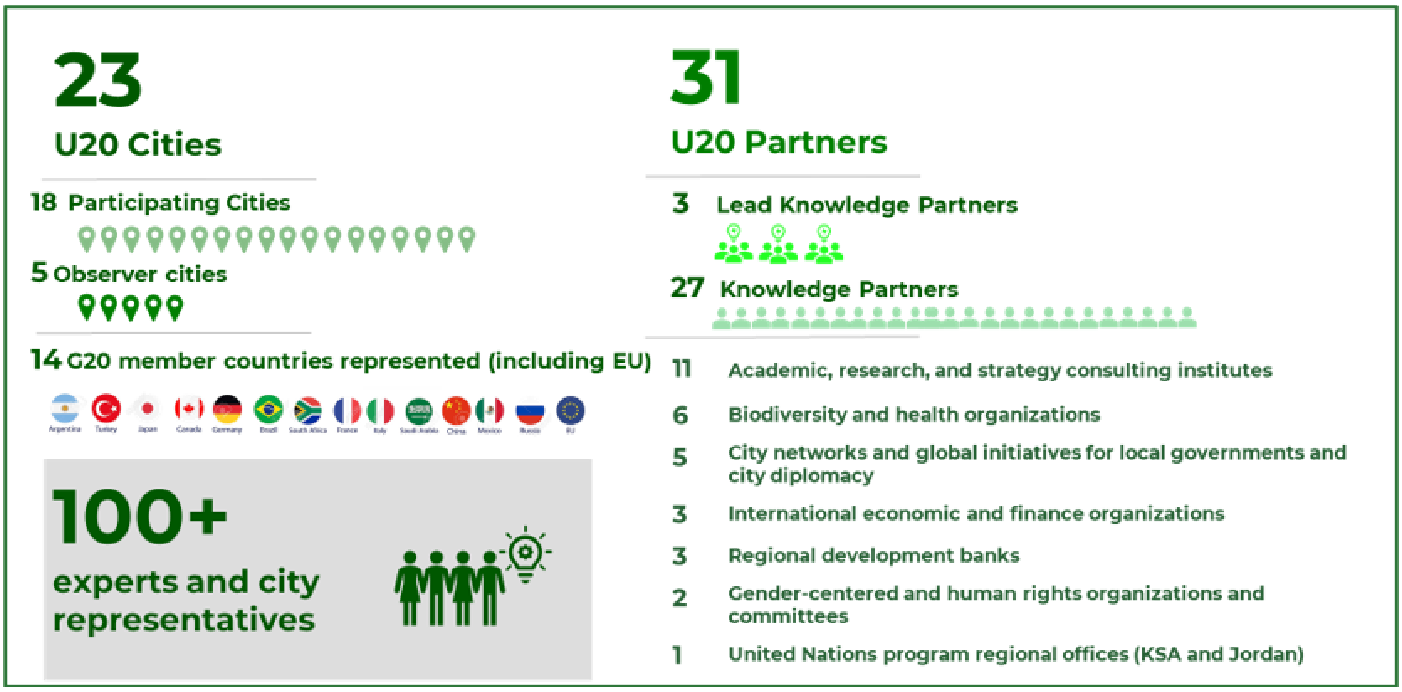
Cities and Partner Engagement

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.



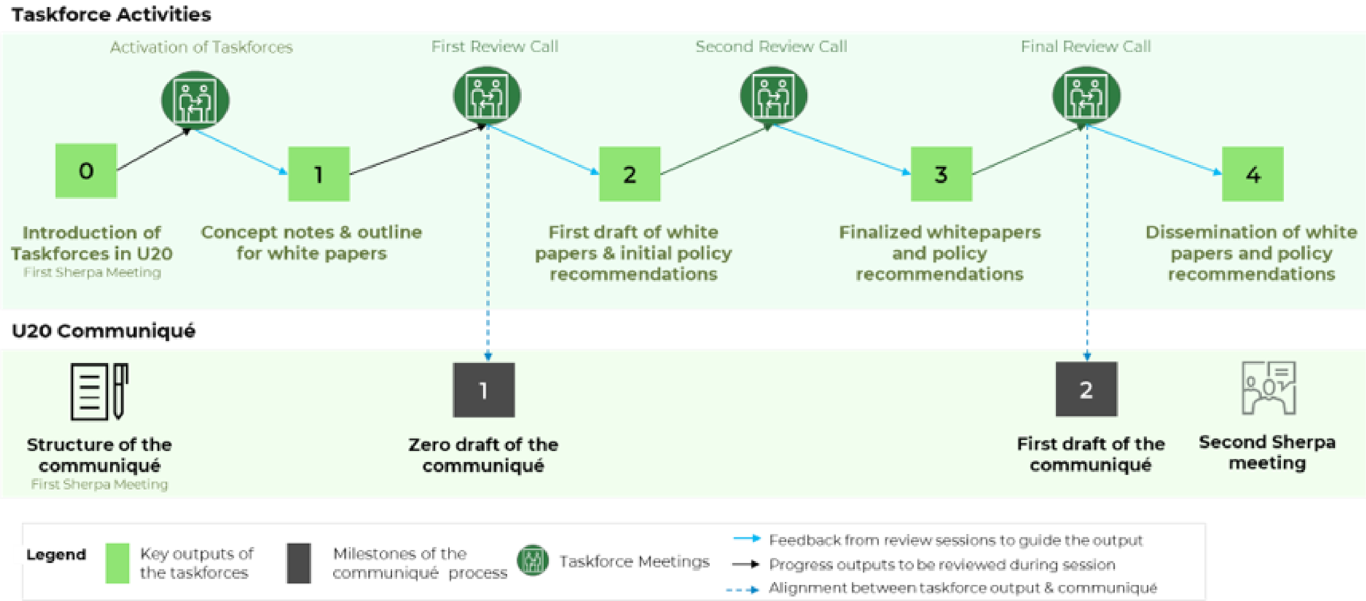
Content Development

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

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

Lead knowledge partner

ICLEI – Local Governments for Sustainability, Cities Biodiversity Centre

About the Authors & About the Contributors

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Executive Summary

Executive Summary

Urban green space interventions are defined as actions that significantly modify the quality, quantity, and accessibility of urban green space (WHO, 2017). They can take the shape of urban parks, bioswales, urban trees, flood parks, riverine areas, green roofs, and natural coastline vegetation. If properly implemented —considering native species, surrounding landscape, and environmental risks—¬each of these interventions has the potential to restore biodiversity in the city and recover important ecosystem services. However, tools to identify, assess, select, and develop urban green space while engaging relevant stakeholders still have room to grow, develop, and become replicable processes.

Local governments often operate under tight budgetary constraints and must face significant trade-offs in terms of service delivery. Not all desirable urban green projects can be funded, while all projects funded should provide greater gains to social welfare than available alternatives. In the case of gray infrastructure, housing, health care services, and other policy areas, local governments often rely on economic analysis to inform their investment decisions. However, urban green spaces and other green infrastructures are not typically assessed at the local level. Approaches such as the Cost-Benefit Analysis or the Cost-Effectiveness Analysis can be adapted to estimate the social value that a specific policy decision (e.g., conservation) or investment option (e.g., developing an urban park) will generate over its life cycle. However, to do this, local governments must first understand how to identify, quantify, and value the benefits provided by urban green spaces and other green infrastructures.

This paper reviews known economic and value assessment methodologies and recommends next steps to policymakers as to how to bolster internal capacity in this subject and what steps they should take in order to use ecosystem service valuation as a decision-making tool.

In this regard we conclude that cities should (1) acknowledge the value of their green spaces; (2) identify partners to develop and include green space in cities; (3) build capacities to assess and compare the benefits of urban green spaces. In addition, Box A summarizes the steps a city should take in order to assess the ecosystem services of its urban green.

Box A

Summary of steps for ecosystem services valuation

Step 1:	Define purpose and endpoints of the valuation
Step 2:	Define the valuation scenario
Step 3:	Biophysical assessment
Step 4:	Identify and validate relevant ecosystem services and benefits
Step 5:	Quantify social benefits (and disservices)
Step 6:	Valuate and assess urban green space

Urban Green and Wellbeing

Urban Green and Wellbeing

What We Know

Urban green space interventions are defined as actions that significantly modify the quality, quantity, and accessibility of urban green space (WHO, 2017). Urban green can take many shapes, including urban parks, bioswales, urban trees, flood parks, riverine areas, green roofs, and natural coastline vegetation. If properly implemented—considering native species, surrounding landscape, and environmental risks—each of these interventions has the potential to restore biodiversity in the city and recover important ecosystem services.

Ecosystem services are the benefits people obtain from ecosystems (MEA, 2005), including (i) **provisioning services** such as food, water, timber, and fiber; (ii) **regulating services** that affect climate, floods, disease, wastes, and water quality; (iii) **cultural services** that provide recreational, aesthetic, and spiritual benefits; and (iv) **supporting services** such as soil formation, photosynthesis, and nutrient cycling (Figure 1). In cities, ecosystem services regulate climate, protect against hazards, improve air quality, support agriculture, prevent soil erosion, and offer opportunities for recreation and cultural inspiration (CBD, 2012).

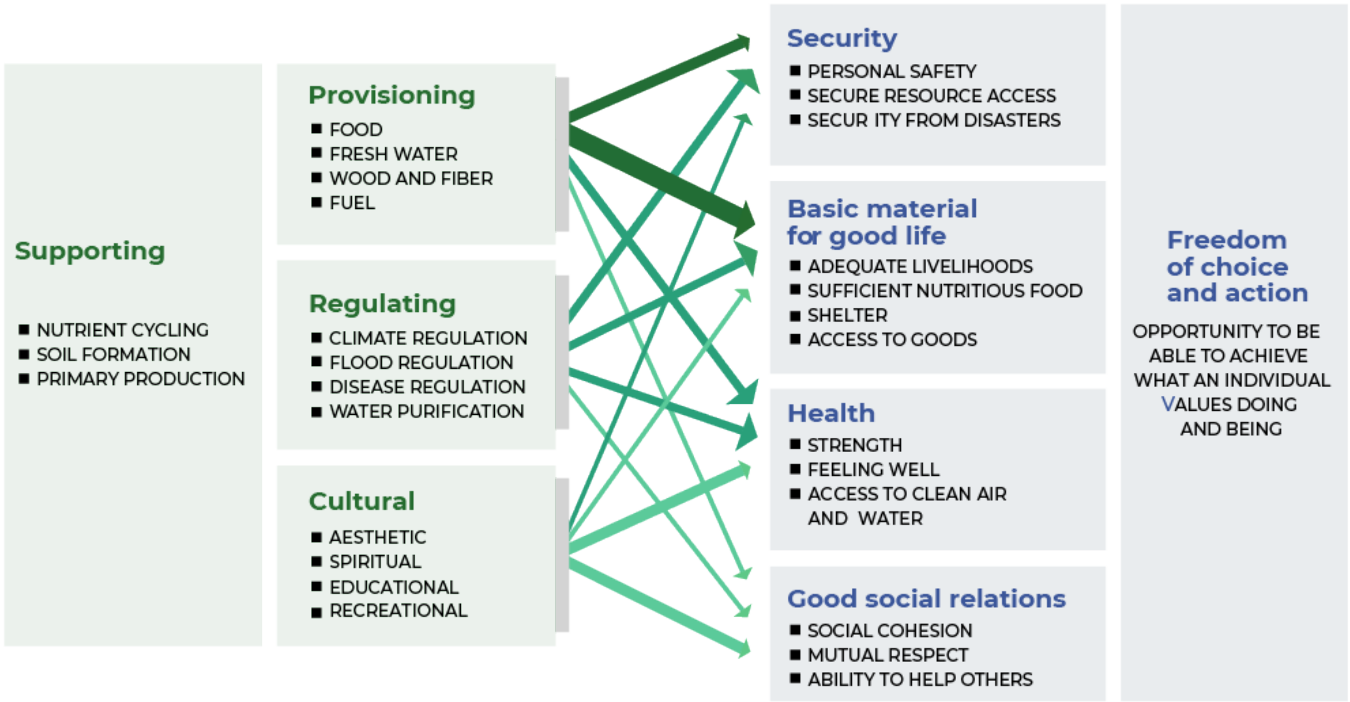
Over the last decades, mounting research has tried to lay out the complex interactions of socio-economic processes with environmental ones (Häyhä & Franzese, 2014), leading to a set of concepts aiming to detangle humanity's relationship to natural capital—understood as the stock of natural resources—and its natural yields: ecosystem services (Costanza & Daly, 1992). Latest convergence on this topic points to nine planetary boundaries (Rockström, et al., 2009; Rockström, et al., 2009) which human activity should not transgress in order to preserve ecosystem services that are key to human survival and well-being (Figure 2). Biodiversity loss is the most surpassed planetary boundary worldwide, even more so than climate change. Planetary boundaries, ecosystem services, and socio-economic dynamics has evolved into a common space where restoring ecosystem services contributes to keeping planetary boundaries and creates a safe operating space for humanity (Raworth, 2012; Rockström, Sachs, Öhman, & Schmidt-Traub., 2013).

Observing the range of ecosystem services listed in Figure 1, ecosystem services can be differentiated between the ones that operate at a global level and the ones whose benefits are deeply localized, meaning that the service they provide is limited to the geography to where the ecosystem exist. This is a key distinction to understand the need for ecosystem services at an urban level: for urban dwellers to access the benefits of ecosystem services they need these services in the cities—and even the neighborhoods—they live in.

Urban Green and Wellbeing

Figure 1.2

Links between ecosystem services and human wellbeing



Source: Adapted from MEA. 2005. Ecosystems and Human Well-being: Synthesis. Millennium Ecosystem Assessment, Washington, DC, USA: Island Press.

Health Improvements

To understand the ways in which urban green contributes to improving air quality, physical activity, and noise pollution, it is important to understand the basic definitions and limitations of these concepts. To this end, Table 1.1 lays out the basic parameters of air quality, physical activity, and noise.

Urban Green and Wellbeing

Table 1.1

Definition and basic parameters of air quality, physical activity, and noise

	Air quality	Physical activity	Noise
Definition	Levels of fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}), Ozone (O_3), Nitrogen dioxide (NO_2) and Sulfur dioxide (SO_2).	Any bodily movement produced by skeletal muscles that requires energy expenditure.	Environmental noise is any noise emitted from all sources except industrial workplaces.
How they are measured	Measured in micrograms per cubic meter ($\mu g/m^3$) and the concentration is expressed over a measure of time. I.e. concentration as an annual mean (a.m.) or as a 24h mean (24h.m.).	Time spent in moderate or vigorous physical activity over a period of time (i.e. day or week).	Noise is expressed in decibels (dB). For health purposes, the amount of time exposed at a certain noise intensity is also relevant.
Causes for poor performance	Solid and liquid particles suspended in air and coming from incomplete combustion in engines, fuel additives, or industrial processes as well as some natural causes.	Sedentary lifestyle. Lack of adequate spaces for physical activity (parks and shaded sidewalks). Criminality on the streets.	Noise, understood as background sounds, is ubiquitous. However, unwanted levels of noise generally come from transport, industrial complexes, or recreational activities.

Urban Green and Wellbeing

	Air quality	Physical activity	Noise

Maximum recommended levels	$PM_{2.5}$: 10 µg/m³ (a.m.) // 25 µg/m³ (24h.m.)
	PM_{10}: 20 µg/m³ (a.m.) // 50 µg/m³ (24h.m.)
	O_3: 100 µg/m³ (8h.m).
	NO_2: 40 µg/m³ (a.m.) // 200 µg/m³ (1h.m.)
	SO_2: 20 µg/m³ (a.m.) // 500 µg/m³ (10-min mean)
		5-17 years old: 60 min of moderate to vigorous physical activity a day.
		>18 years old: 150 min of moderate activity a week or at least 75 of vigorous activity a week.
			WHO has a detailed list of limits considering the situation and duration (WHO, 1999; WHO, 2018).
			The most common recommendation is not to exceed 50 dB in outdoor noise and 30 dB for sleeping hours. However, there are specific values and time durations for different events.

Burden due to death or disability	4.2 million deaths a year 8,7 Million DALY in 2009 (WHO, 2009)	3.2 million deaths a year in 2009 32 Million DALY in 2009 (WHO, 2009)	4,5 Million DALY (WHO, 2009)

Source: Unless explicitly cited, data in this table was extracted from different World Health Organization official factsheets (WHO, 2018; WHO, 2018).
[1] Social burden, expressed in deaths or disability-adjusted life years (DALYs), which measures equivalent years of "healthy" life lost by virtue of being in states of poor health or disability.

Urban Green and Wellbeing

Urban green improves health in the following ways:

1. **Air quality**: Urban green improves air quality through several pathways. Firstly, urban trees can capture particulate pollutants and gases. Some species are better than others doing this; pines, larches, and silver birches, are the most efficient, while oaks, willows and poplars, have mixed results (Donovan, Stewart, Owen, Mackenzie, & Hewitt, 2005). Secondly, urban green provides shade and creates evapotranspiration processes, both of which lower the temperature, slowing down the production and chemical activity of tropospheric ozone (Royal Commission on Environmental Pollution, 2007). On higher layers of the atmosphere (stratosphere), ozone protects humans from ultraviolet radiation, however, in its lowest level, (troposphere) ozone is the main component in *smog* which is present in the air we breathe and damages human tissues.
2. **Physical activity**: Urban parks and trees provide space to develop physical activity, either by providing the infrastructure where people can actively practice it, or by providing shaded sidewalks, encouraging commuting options that involve physical activity. Although there are behavioral elements involved, research shows that urban green accessibility has a significantly positive correlation with residents' physical activity patterns (Wang, Dai, & Wu, 2019; Smith, Hosking, & Woodward, 2017).
3. **Noise**: Urban green attenuates noise, particularly when it comes to traffic activities. Research shows that both urban tree rows and parks have potential for noise abatement, although mixed infrastructure involving grey engineering covered in green infrastructure seem to be the most effective (Wolf, Krueger, & Flora, 2015). Additionally, urban green not only mitigates man-made noises but also produces noises of its own, which humans subjectively prefer to those man-made (Pheasant, Horoshenkov, Watts, & Barrett, 2008).

There is sufficient evidence as to how and why urban green abates the physical parameters that cause poor air quality, lack of physical activity, and harmful levels of noise. However, quantifying the exact health benefits from the ways in which urban green interacts with these parameters is a challenging task, since overall health outcomes are underpinned by many factors that include behavioral, social, genetic, and environmental causes. Despite this barrier, there have been several attempts to quantifying them, with myriad research (Box 1.1) verifying their merits. Poor communities, children, pregnant women, and senior citizens particularly benefit from these services.

Urban Green and Wellbeing

Box A

Research conclusions on health and urban green

- 10% increase in tree canopy cover within 50m of a house could lead to lower number of low weight babies (Donovan, Michael, Butry, Sullivan, & Chase, 2011). This association is robust to adjustment for air pollution and noise exposures (Hystad, et al., 2014).
- More residential tree cover in urban neighborhoods is related to better overall health and social cohesion (Ulmer, et al., 2016).
- Urban tree cover causes significant benefits towards psychological functioning as opposed to grey infrastructure—improving depression and mental health, including those of children (Berman, Kross, & Krpan, 2012; Beyer, et al., 2014; Andrusaityte, Grazuleviciene, Dedele, & Balseviciene, 2020).
- There is a correlation of urban tree cover and improvement in physical health, i.e. reducing obesity, lowering the risk of cardiovascular disease, ischemic heart disease, and stroke mortality after adjustment for ambient air pollution (James, Banay, Hart, & Laden, 2015).
- Lack of access to nature in cities, and associated sedentary, indoor lifestyles, is linked with physical and mental health disorders including vitamin D deficiency, asthma, anxiety, and depression (Gelsthorpe, 2017).
- Harmful levels of noise cause health conditions like cognitive impairment, stress, sleep changes, hypertension, and cardiovascular diseases (EEA, 2015; WHO, 2018), with an estimated annual cost of 40 billion euros a year in the EU (European Commission, 2011).
- Urban green belts can reduce background noise up to 10 dB (Martens, 1981).

Wellbeing

Urban green provides a more intangible and less measurable ecosystem service than regulation services that improve environmental quality. It has a socio-cultural value, which is deeply intertwined with a city's identity, social cohesion, aesthetic appeal, and recreational offer. Indeed, research confirms that experiencing nature in the urban environment is "a source of positive feelings and beneficial services, which fulfill important immaterial and non-consumptive human needs" (Chiesura, 2004).

Urban Green and Wellbeing

Although it is commonly acknowledged that these intangible services are essential for sustainable cities (Terkenli, et al., 2017), the difficulties in quantifying them bring barriers to its environmental assessments. This hinders the possibility to defend its deployment, since many times urban planning processes are framed from an economic perspective where monetary value is given to improvement versus degradation (Yengué, 2017). Even where monetary value allocation has succeeded, few studies consider the variability in value for different citizen groups: accessibility measures the availability of green space, so diverse benefits of urban green space are not always accounted (Zhou & Parves Rana, 2012).

Common Standards

There is not a commonly agreed standard of how much green a city should have. Common measures include population-ratio, green area percentage within a city, or ecological catchment area. There is the common conception in urban planning literature (Russo and Cirella 2018, M. &. Maryanti 2016) that at some point the World Health Organization proposed an urban green/ person ratio of at least 9 m2; however, this study was unable to find an official source from WHO stating such number. A review of standards used in different cities across the globe yields a range between 8 and 50 m2 of urban green areas per capita (Russo and Cirella 2018, Maryanti, Khadijah y Uzair 2016); however, there is not a universal number.

In addition, the amounts of green space per capita alone is not enough to ensure that ecosystem services reach as many urban dwellers as they need to. There are several factors like accessibility and quality that influence the overall outcome of deploying urban green. For example, a plan to make England's urban green more accessible (Natural England 2010) suggested that for everyone to enjoy sufficient and accessible urban green everyone should access parks of (i) at least 2 hectares in size, no more than 300 meters from home; (ii) at least one accessible 20 hectare site within two kilometers of home; (iii) one accessible 100 hectare site within five kilometers of home; and (iv) one accessible 500 hectare site within ten kilometers of home; plus (v) a minimum of one hectare of statutory Local Nature Reserves per thousand population.

An additional layer of complexity to how much urban green is enough comes from the behavioral and programmatic use of the space —parks managed to have activities where users can engage will benefit more efficient use from the ecosystem services provided by that park.

Urban Green and Wellbeing

Indicators

While there is not a universal number to achieve in terms of how much green a city should have, the World Health Organization does provide some guidance regarding how to keep track of the adequacy of existing urban green space (WHO, 2017). In this report, WHO recommends keeping track of the following parameters:

- Availability
  - Greenness measured by Normalized Difference Vegetation Index (NDVI).
  - Density or percentage of green space by area.
  - Measures of street trees and other streetscape greenery.
- Accessibility
  - Proximity to an urban park or geographically defined green space.
  - Proportion of green space or greenness within a certain distance from residence.
  - Perception-based measures of green space accessibility.

Organizations with a more practical approach to implementation provide more thorough lists of measurements to guide urban green measurement exercises (CABE, 2010):

- Quantity: used to measure absolute and relative amounts of urban green by type of green space. Indicators can include:
  - Area of green space per population.
  - Area used for sports/leisure per population.
- Quality: including subjective assessments such as resident satisfaction and objective measures such as biodiversity. Indicators can include:
  - Number of quality parks recognized by the local authority.
  - Percent of households satisfied with nearby urban green.
  - Environmental quality of park location
- Use: how people use green space. Indicators could include:
  - Percent of people using green space by frequency.
  - Percent of people who are physically active.
- Proximity: the physical location of green space in relation to where people live, and how far people must travel to access different types of green space. Indicators could include:
  - Homes within X meters of a natural green space of at least Y hectares.
  - Measure of proximity to green space for those in the most deprived areas.
- Value: capturing how important green space is to people.
  - Percent of people who think that local parks and open spaces are important in making somewhere a good place to live.
  - Percent of people who think access to nature near to where they live is important.

Urban Green and Wellbeing

However, these measures apply only to parks, and not other forms of urban green, such as urban street trees or the interaction between public and private parks. Some cities are taking particularly innovative approaches on this area of practice. Singapore, a city-state particularly challenged by rising population and limited land has managed to include biodiversity in city planning in innovative ways, ensuring access to ecosystem services and quality of biodiversity despite strict space limitations (Case Study 1). Montréal, on the other hand, has been able to set innovative targets that not only take into consideration percentage of land as protected areas but also canopy coverage, and the deployment of urban street trees (Case Study 2).

Case Study 1: Singapore Urban Biodiversity Index

- As a city-state with a land area of 720 km2 and 100% urbanized, Singapore has undertaken a unique effort in measuring and deploying urban green, achieving 350 parks and gardens, 1300 community gardens, 100 ha of skyrise greenery, 313 km of park connectors, 80 km of nature ways, 2 million urban trees, and 3,347 ha of nature reserves (Er, 2018).
- In 2016, Singapore released a measuring approach to urban greenery, providing guidelines that request a minimum green plot ratio of 4.5 in all new public housing developments. This ratio considers the total leaf area of greenery per development site area (Ong, 2003), taking account of the number of plants, canopy size of trees, how leafy they are and how closely they are planted. The provision also requests a green cover of 45 to 60%; this measure differs from the first one in the fact that this is just a percentage that takes into consideration only the aerial vision of green surface.
- Additionally, the city developed the Singapore Index on Cities' Biodiversity, which is used by at least 26 city governments. This Index assesses the performance of cities in 23 indicators covering three core areas: (1) native biodiversity in the city; (2) ecosystem services provided by the biodiversity; and (3) governance and management of biodiversity. The areas weigh 40 (10 indicators), 16 (4 indicators) and 36 (9 indicators) points respectively; with each indicator having a maximum of 4 points (Chan, et al. 2014, L. Chan 2019).

Urban Green and Wellbeing

Case Study 2: Enhancement and strengthening of Montréal's urban forest

- Sustainable Montréal 2016-2020 set targets to increase the agglomeration's canopy index (area of canopy) from 20% in 2015 to 25% in 2025, as well as extending the protected areas to reach a 10% of the agglomeration's terrestrial area (Ville de Montréal 2016).
- To enhance canopy cover throughout Montréal the City, in coordination with a local non-profit, undertakes planting activities that resulted in 20,000 additional trees.
- To maximize the benefits and to promote planting trees in heat islands, a program has been implemented to remove concrete and built large plantation pits in paved areas, so that planted trees can take deep rooting and develop a large canopy.
- To enhance resilience of the urban forest and its benefits, tree species must be diversified, especially, to reduce risks associated to extreme disturbances and introduced pests. To this end, an analysis of the composition of arboreal assets is carried out to improve, the diversification and resilience of the whole urban forest.
- Additionally, to promote adhesion of stakeholders, standardized technical specifications have been developed in partnership with civil engineers, urbanists, landscape architects and foresters.

In a recent publication from the Inter-American Development Bank, a variety of tools to deploy urban green are analyzed, taking into consideration three shifts in conceiving, building, and maintaining parks and other urban greens (Parente, 2020). First, parks are increasingly expected to perform functions of resiliency, in addition to being spaces for recreation. Second, urban green is the result of a convergence of interests across city and state government, the private sector, and civil society. Third, the sizes and legal status of each green urban space depend on the planning and designing capacity of local entities.

In this context, tools in favor of urban green need to offer guidance to answer key questions. Who benefits from the broader land use changes often linked to new or redeveloped parks, and who stands to lose? What is the scale of the zoning changes (ranging from an entire neighborhood to a block) and the impact of the broader strategies? To what degree will city government include measures to capture some of the private benefits generated by public expenditures, either to maintain and repair parks or to provide other public goods, such as affordable housing?

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Case Study 3: Partnerships to create capacity building programs. Examples from the Global Alliance on Health and Pollution (GAHP)

- The Global Alliance on Health and Pollution (GAHP) is an collaborative body of 60+ members that advocates for resources and solutions to pollution and health problems. GAHP member urban space projects have included remediation of contaminated beaches and housing development plots, and urban watershed management for clean water and improved urban fisheries management. All these projects systematically include a capacity-building component to benefit stakeholders.
- Activities include the creation of a coordinating body with representatives of the civil society, and the public and private sectors; as well as the development of instruction manuals to accompany the investments and guarantee the transfer of knowledge.
- For example, in Sumgayit, Azerbaijan, GAHP member Pure Earth developed a beach remediation project that included capacity-building activities and coordination between the various ministries and the local stakeholders in addition to the core exercise which was to clean the site, plant native trees and shrubs to prevent erosion and create a green space for local residents.
- In Cinanka, Indonesia, GAHP member Pure Earth remediated a lead-contaminated football pitch, burying contaminated waste under the field in Indonesia's first hazardous waste containment facility. Clean soil and turf was placed on top for local children and adults to play without being exposed to dangerous levels of lead.

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The most successful examples in New York City have provided the city with new parkland while also contributing to the functioning of other strategic urban needs, including housing, non-motorized transit systems, flood protection, and the redevelopment of formerly abandoned industrial sites. They have done so by using novel institutional arrangements to leverage public funds to catalyze private investments while ensuring mechanisms exist to capture some of these benefits, or by directly targeting existing inequalities by publicly funding parkland while creating novel partnerships with civil society actors and across governmental agencies.

For example, storm water management techniques, including use of dry detention ponds and constructed wetlands can help not only mitigate devastation due to flooding, but also reduced peak storm water runoff rates, rehabilitate and preserve natural landscapes and wetlands and improve water quality. It does so by allowing storm water to seep into the ground to be naturally filtered by soil and rocks, as opposed to non-mitigated street, building and backyard runoff which picks up pollutants such as oil, chemicals, pesticides and other materials which then flow into urban canals, sewers and other waterways. Restored wetlands in urban areas provide healthy habitat for fish, amphibians, insects and birds, and also serve as storm water basins that can purify water. When combined with dry detention ponds, they create parkland during dry periods. Dry detention ponds help control the runoff rate, temporarily storing water for gradual release to downstream areas.

Looking at Dutch development strategies, adaptive planning based on creating the conditions of development can be more successful than a traditional take on planning, focused on content and process (Rauws & Roo, 2016). The application of socio-ecological resilience in urban spatial planning is often included in the adaptive planning approach. It can reinforce ecological consideration in the demand allocation of UGS as an alternative approach to the existing "standard approach," which based on population number. The literature highlights the importance of analyzing the dynamic interaction of socio-ecological systems (complex and adaptive) in spatial planning, especially in determining demand allocation of UGS (Afriyanie, Akbar, & Suroso, 2018). Under this framework, resilience planning for UGS needs to answer "5W" (what, who, when, where, and why) questions to prioritize which functions and benefits of UGS will be prioritized and where.

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Table 1.2

Example of application of the “5 W”

		Scenario 1	Scenario 2
Who?	Trade-offs	Beneficiaries are city residents living in flood risk zones.	Beneficiaries are city residents with most limited access to green space.
What?		Specifically focused on storm water management.	Generic community resilience.
When?		Focused on current residents and based on current estimates of risk.	Both short-term and long-term resilience.
Where?		Neighborhoods with the most area in flood hazard zones within the municipal boundaries.	Neighborhoods with the lowest average access to green space within municipal boundaries.
Why?		Goals is an outcome: flood losses and investments in “gray” storm water infrastructure are reduced.	Goal is an outcome: increased social justice

Source: Meerow, Sara, and Joshua Peter Newell. 2016. "Urban resilience for whom, what, when, where, and why?" Urban Geography

Adaptive urban strategies have also been used to rethink green open space in cities. As part of the URBELAC network, the city of Bordeaux presented how it developed a plan to improve and enlarge urban open space (European Commision, n.d.). The firm drafted guidelines and developed tools for a unified design concept, a “Charte des Paysages”, or landscape charter. In association with this concept, it developed a concrete planning culture together with the city’s office for Urban Ecology, Environment and Open Space Planning, which also took over construction of the projects. The method developed consisted of a series of case studies: spatial unity, borders, typologies, levels, soils, and open space structure were analyzed, and draft projects were tested on site in order to define the spatial, aesthetic, functional, and ecological impacts.

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The strategy of expansion of greening in urban planning could play an important role in enhancing the resilience of cities and communities. Green spaces have the potential to be part of an integrated socio-ecological system that connects natural and built environment and mitigates natural and climate risks. In that context, risk studies highlight the need of conceiving the city as an entity connected to its territory of influence (Suarez, Esquivel and Zuloaga 2020).

The deficit in natural areas, along with weak coordination between built and natural landscape, limit the ability to leverage the services provided by cities and ecosystems. Green areas are generally populated by introduced (non-native) species that require large amounts of water, or different types of soil placing pressure on their environmental sustainability. The lack of a healthy, well-conserved urban tree canopy contributes to the "heat island" effect witnessed in most cities in the region. Historically, the quality and adequacy of green areas have not been a priority on local governments' agendas; vegetation has been planted without prior consideration of its environmental characteristics and poorly maintained thereafter.

The following boxes describe how Riyadh, Strasbourg, and Amman deployed urban green successfully. Their success is a reminder that the two main components to the inclusion of urban green in cities is to create participatory instruments that facilitate tradeoffs and can act as enabler for the design, creation, and maintenance of green space.`

Case Study 4: Local participation at the center of urban green design in Strasbourg

- Strasbourg created a participatory system where volunteers and local stakeholders carry out a shared diagnosis and co-create a proposal and action program to be proposed to the Mayor and partners so that everyone can get involved and identify the actions they wish to contribute.
- This methodology allows for inhabitants to identify spaces to be protected and makes it possible to enhance a territory by putting its heritage elements and its inhabitants' needs into perspective. It is particularly suited to the outskirts of cities when the center generally draws all the attention.
- It provides a structuring and global approach: structuring the fabric of the territory in coherence with the Local Plan of Inter-Communal Urbanism to allow an articulation between the strong dynamic of urban development and the requirement of climate change and adaptation. It not only enhances green or natural spaces, but creates an ecosystem favorable to nature, to the city, and to its inhabitants.

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Case Study 5: An integral plan to deploy urban green in Riyadh

- Riyadh has its Green Riyadh project underway, which will deploy UGS with a multi-pronged strategy aiming at providing the city with climate resilience, better air quality, improved health, and access to ecosystem services.
- The project targets an increased vegetation coverage in Riyadh from the current 1.4% to 9.1% by 2030. It aims to increase the city's per capita green space from 1.7 to 28 m^2. This green space is projected to (i) decrease temperature by 2 degrees on average during summer; (ii) reduce temperature by 8 to 15 degrees in selected areas; (iii) reduce particulate matter suspended in air; (iv) capture carbon; (v) manage rainfall; (vi) provide the space for citizens to undertake physical activity; and (vii) improve urban landscape and preserve local biodiversity.
- 7.5 million trees from 72 native shade species will be planted across the capital in gardens, parks, mosques, schools, healthcare facilities, the airport, and most of the city's roads, streets, utility lines, car parking spaces, and valleys by 2030.
- The program includes repurposing the centrally located old Riyadh airport to create an urban park that will be connected to multiple public transportation hubs and is planned for multi-use, with residential and commercial venues surrounding the park and spotted within it.
- The program is supported by hard enablers, such as the establishment of tree nurseries, the increase of water recycling infrastructure for irrigation, the enhancement of soil quality, and tools for the operations; as well as soft enablers, such as the adoption of new regulations and standards, incentives schemes for the private sector, communication campaigns to raise awareness and voluntary participation, and the establishment of a fund to support operations, awareness, and incentive schemes.
- The project is expected to have 71 billion SAR (1.8 billion USD) as return of investment by 2030, through less healthcare expenses, lower electricity consumption, higher real estate value, and use of treated wastewater in irrigation as a replacement for potable water.

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Case Study 6: Amman forest creation for a resilient city and instruments to boost urban green

- The Greater Amman Municipality (GAM) has been renovating 70 parks and gardens in the capital, as part of a three-year plan. Part of the strategy is to create urban forest to tackle the global challenges of climate change, pollution, degradation of ecosystems, disruption of water cycle, drought, soil erosion, desertification, habitat fragmentation and loss, biodiversity loss, and species extinction.
- The green strategy is partly operationalized through Project Miyawaki, which focuses on creating "Indigenous Authentic Forests" to restore ecosystems in urban and rural areas. The project involves researching the Potential Natural Vegetation (PNV) of different locations, engineering solid and water infrastructure for intervention areas, and re-establishing the native plant communities in these areas. This project also involves capacity development in soil building techniques and production of native species.
- The Methodology involves soil survey, species survey, soil engineering, dense plantation, and maintaining forests for two years so they can be self-sustained later with minimum supervision. These forests are 30 times denser and have 30 times more ecological and socio-economic benefits than the conventional plantations. The unique structure of these forests has an exceptional advantage in natural disaster prevention, allowing these forests to form protective buffers from flash floods, linking two major goals of GAM in one solution. Unlike the artificial native monoculture and foreign polycultures forests that already exist in Amman, the Miyawaki method creates indigenous authentic forests that are expected to survive for thousands of years.
- Policy tools to boost green space in GAM include (1) exempting developers from paying the construction permit fees in hopes of increasing the green cover in the city and (2) new regulations for plots that exceed 4000 m2 in the new Planning and Building Regulations issued in 2019 that states the need to provide 10 m2 of green spaces per apartment on the plot.

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Case Study 7: Durban deploying & sustaining urban green in center of biodiversity hotspot

- Durban is situated in the center of a Global Biodiversity Hotspot, namely the Maputaland-Pondoland-Albany (MPA) region (Hrdina & Romportl, 2017). To enhance biodiversity and make use of its vast ecosystem services, Durban (1) sought to increase the amount of conservation land and (2) developed the Durban Metropolitan Open Space System (DMOSS) in order to keep track of the state of current UGS.
- DMOSS is the primary tool in the protection and management of natural resources in the area. The system connects almost 95,000 hectares of public, private, and traditional authority-owned urban green, considered to be the minimum area to achieve the city's biodiversity targets.
- The system has progressed from focusing on only species and habitat protection to include the recognition of ecosystem services. Other considerations have included a growing focus on the implementation of the plan, the restoration of ecosystems, and growing concerns related to the impacts of and adaptation to climate change.
- As a result, any planning application for a site included or adjacent to a site in the system needs to be assessed by the environmental authority (Boon, et al., 2016). This fact helps sustain the natural areas in spite of the fact that only 8.2% of the total green areas in DMOSS are legally protected.

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Local governments often operate under tight budgetary constraints and must face significant trade-offs in terms of service delivery. Not all desirable projects can be funded, while all projects funded should provide greater gains to social welfare than available alternatives. In the case of gray infrastructure, housing, health care services, and other policy areas, local governments often rely on economic analysis to inform their investment decisions. Approaches such as the Cost-Benefit Analysis or the Cost-Effectiveness Analysis can be employed to estimate the social value that a specific investment option will generate over its life cycle, and then compare it to alternative options. If done right (e.g., pluralistic, participatory, and technically sound), economic analyses can improve the quality of public spending, helping local governments meet the demands of their constituencies while promoting sustainable growth.

While the economic toolbox is commonly used by local governments across the world to assess grey infrastructure projects, the same does not occur for green infrastructure. Local governments often lack the tools and frameworks to estimate the multiple benefits (and sometimes disservices) that green and natural infrastructures provide to society. The limited ability of local governments to assess urban green in standard economic terms has biased decision-making toward single-purpose grey infrastructure and undermined the role that conservation can play for the development of healthy, inclusive, and resilient cities (Center for Neighborhood Technology, 2010). Therefore, helping local governments identify, quantify, and evaluate their natural assets and green infrastructures is an important step toward increasing municipal investment into conservation and nature-based solutions.

The following sections present a series of concepts, methods, resources, and examples related to the economic assessment of the services and social benefits provided by UGS and other green infrastructures at the local scale.

Economic Valuation of Ecosystem Services: An Overview

Economic assessments such as cost-benefit analyses compare the social costs and benefits of a good or service during a defined period. Social costs and benefits can be private, like the cost of maintaining a tree in the patio of a private residence, or the shade that tree provides for the residence, or external, like the air purified by the tree. Most private costs and some benefits can be approximated through market prices, but external costs and benefits require a measure of the value society assign to the good or service in consideration—typically approximated by the Willingness to Pay.

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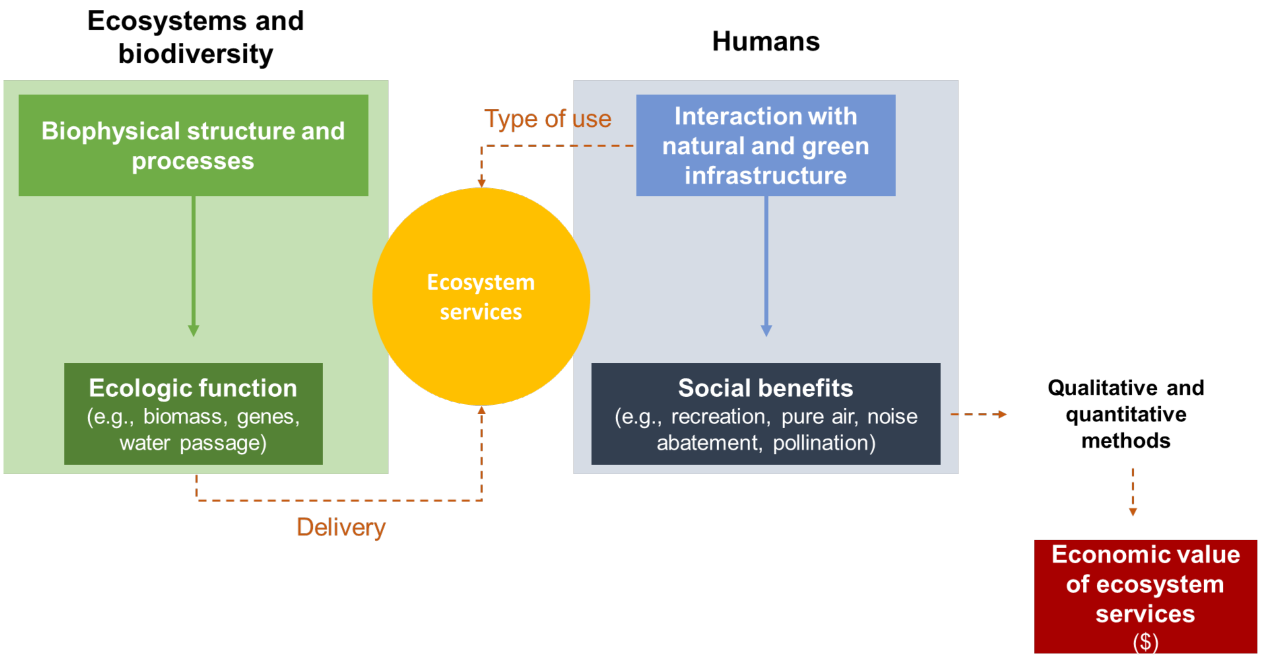
The ecosystem service approach is a widely used framework to assess the value of natural assets and green infrastructure (Hassan, Scholes, & Ash, 2005). The ecosystem services approach is useful for economic valuation because it ties together the ecological functions of ecosystems with the social value people obtain from them (see Section 1.1). Moreover, the ecosystem services approach allows the analyst to simulate how changes in the quantity or quality of green or natural infrastructure could affect human wellbeing. Of course, this approach is not free of criticism; assessments that concentrate on ecosystem services are anthropocentric by definition and ignore other types of natural value such as sustaining biodiversity or its intrinsic value (Schröter, et al., 2014).

Figure 2.1

From ecosystem function to economic value: a simplified view



Source: authors elaboration, based on Bastian, O, K Grunewald, and D Haase. 2010. "Linking ecosystems functions and ecosystem services." Salzau Conference on Solutions for Sustaining Natural Capital and Ecosystem Services: Designing Socio-Ecological Institutions".

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Valuating the services—and disservices—delivered by ecosystems is not an easy task. The ecosystem services delivered by a natural asset or green infrastructure, and hence the social benefits generated by it, depend on how people interact with it; for instance, every UGS provides multiple ecosystem services, and not every UGS delivers the same kind of services. Some people may enjoy the benefits provided by an ecosystem by direct use (e.g., appreciation of landscapes), some others may be benefited by indirect use (e.g., noise attenuation in residential areas near urban forests), and some even may obtain value by non-use (e.g., the satisfaction that future generations will enjoy a specific natural asset) (Barton, Harrison, Sander, & Martin-López, 2017, p. 75). Each type of ecosystem service and each type of use is different and requires different considerations. Because of this, there is no cookie-cutter method for economic valuation.

The valuation of ecosystem services can be expressed either in monetary or non-monetary terms. Monetary valuation is currently the mainstream approach as it provides standardized, comparable, and easy-to-interpret estimations that can be used to inform policymaking or investment decisions. However, monetization of social benefits provided by ecosystems is not always feasible or even desirable. Monetization can oversimplify the value of ecosystem services, lead to biases—usually those ecosystem services that are easier to valuate are the ones that end up being valued—and may not work for ecosystem services such as "spiritual value" or "sense of place", that have no direct market price or surrogate markets (Haase, et al., 2014; Hernández-Morcillo, Plieninger, & Bieling, 2013). On the other hand, non-monetary approaches, such as the family of socio-cultural valuation methods can be broader in scope, leading to a richer understanding of the social value of ecosystem services, but often generate results that are not easy to interpret or compare with other policy or investment options.

Below, we summarize the main monetary and non-monetary valuation methods for ecosystem services used at the global and regional scale. We discuss further the selected methods on Appendix 1. In sections 4.2 and 4.3 we discuss specific methods that can be used at the local scale to valuate UGS.

This document presents several valuation methods to estimate the benefits delivered by ecosystems; that is, the document focus on the supply-driven methods. However, this is not the only approach to value ecosystem services. Although less common, valuations exploiting the demand for specific ecosystem services do exist (for instance Honey-Rosés, et al., 2013).

[2] This document presents several valuation methods to estimate the benefits delivered by ecosystems; that is, the document focus on the supply-driven methods. However, this is not the only approach to value ecosystem services. Although less common, valuations exploiting the demand for specific ecosystem services do exist (for instance Honey-Rosés, et al., 2013).

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Table 2.1

Monetary valuation methods for ecosystem services

Approach	Method	Type of use analyzed	Ecosystem services valued	Strengths	Weaknesses	Data and technical req.	Relevant & feasible at local level	Key references
Price-based	**Market Prices**	Direct and indirect use	Services that contribute to a marketed prodct, or are directly marketed. Usually provisioning and supporting services (e.g., fiber, fish)	Availability of robust market data	Limited to ES contributing to products with defined markets. Not strictly a measure of utility.	[green]	[green]	Obidzinski et al. (2012); Rist, Feintrenie, & Levang (2010); Spangenberg & Settele (2009)
	Cost-based methods	Direct and indirect use	Services that could be replaced with engineered solutions. Usually regulating and supporting services (e.g., mitigation of stormwater runoff)	Availability of robust market data	Likely to overestimate the value of the ES (e.g., if the most efficient technical solution is not valued). Not strictly a measure of utility.	[yellow]	[green]	Barton, Harrison, Sander, & Martin-López (2017); Singh, Pandey, & Chaudhry (2010)
	Production function	Indirect use	Ecosystem services that serve as inputs in the production of marketed products. Usually supporting services (e.g., pollination)	Methodologically sound, consistent results. Availability of market data	Data intensive. Requires significant modelling capabilities.	[red]	[red]	Swinton et al. (2007); Hanley et al. (2015); Ricketts (2004)
Revealed preference	**Hedonic prices**	Direct and indirect use	Ecosystem services that do not have a direct market price, but can be appreciated by people, and influence their desicionmaking	Methodologically sound. Availability data for surrogate markets	More suited to value observable environmental amenities than ES. Data intensive.	[red]	[green]	Peterson (2003); Nijkamp, Vindigni, & Nunes (2008)
	Travel cost	Direct and indirect use	Cultural and recreational ecosystem services. Especially suited to valuing recreational sites	Based on observed behavior. Easy to interpret results	Data intensive. Requires intensive modelling and GIS capabilities	[red]	[red]	Peterson (2003); Boyd (2012)
Stated prefeence	**Contingent valuation**	Use and non-use	Most ecosystem services. Most useful for services than can be easily qualified/quantified by respondents	Can capture use and non-use on wide range of ES. Pluralistic	Costly. Dependent on hypothetical markets. Subject to diverse sources of bias	[yellow]	[green]	Barton, Harrison, Sander, & Martin-López, 2017; Chaikaew (2017)
	Choice experiment	Use and non-use	Most ecosystem services	Can capture use and non-use on wide range of ES. Pluralistic	Costly. Dependent on hypothetical markets. Subject to diverse sources of bias	[yellow]	[green]	He, Dupras, & Poder (2017); Brander, et al. (2010)
Value transfer	**Benefit transfer**	Use and non-use	Can be applied to almost all ecosystem services and types of use. Usually when local data, resources or technical capacities are limited	Ease of use. Based on available data. Low cost	Values of existing studies may not be directly transferable, leading to biases in estimation. Not pluralistic	[green]	[yellow]	Boyle & Parmeter (2017); Plummer (2009); Turpie, Letley, Chyrstal, Corbella, & Stretch (2017)

Source: Adapted from Defra (2007, p.37), with additional inputs from Barton, Harrison, Sander, & Martin-López (2017).
Red: high data and technical requirements, low feasibility or relevance at local level; yellow: moderate data and technical requirements, medium feasibility or relevance at local level; green: low data and technical requirements, high feasibility or relevance at local level.

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Valuation Approaches for Ecosystem Services of Urban Green Spaces

Cities across the world are increasingly turning their attention to nature-based solutions and ecosystem-based approaches to urban planning as means to deliver sustainable and cost-effective solutions to their development challenges, especially those related to water management, risk mitigation, conservation of biodiversity, air quality, wellbeing, and public health (Raymond, et al., 2017). Green infrastructures[3] have a significant role to play in achieving more resilient, inclusive, and sustainabledevelopment in cities. Recent research suggests that UGS can significantly reduce the financial burden of municipal services; increase local revenues via property tax; boost local economic development through tourism, entrepreneurship, and green jobs; promote private reinvestment in urban areas; and strengthen community cohesion (Kastelic, 2014).

However, green infrastructures—and UGS in particular—are still not widely viewed as means to foster sustainable development, and thus are rarely included in the planning processes of cities as such. To leverage the full potential of UGS and balance the current bias toward engineered solutions, local governments need tools and frameworks to assess their social value and express it in standardized terms that facilitate their understanding in non-technical circles and could lead to their inclusion into planning and investment decision-making.

Although the global ecosystem services literature has grown rapidly, providing scientific and policy communities with several valuation frameworks and methods (see section 2.1), the valuation of urban ecosystem services (i.e., those provided by ecosystems and natural assets in urban spaces) has not been developed as thoroughly, and has mostly focused on: (i) monetary valuation; (ii) specific ecosystem services rather than natural assets, which provide bundles of ecosystem services; and (iii) high-income cities in the western hemisphere (Haase, et al., 2014). We lean on the work of Berghöfer, et al. (2011), Gómez-Baggethun & Barton (2013), Raymond, et al. (2017) and (IDB, 2020) to put together a set of guiding principles and methods that cities can adapt to their unique contexts and use to build their own frameworks for valuing urban ecosystem services. These principles and methods are focused on ecosystem services related to UGS but can easily be adapted to other typologies of green infrastructure.

[3] A concept that encompasses urban green spaces, street trees, permeable surfaces, community gardens, or green roofs and walls delivered as standalone assets or as a network.

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What urban ecosystem services to value and how to value them depends on scale, functionality, ubiquity of UGS, objective of the valuation, local capabilities, and available resources.

Valuation of ecosystem services at the local scale is not, and should not aim to be, the same as valuations at the regional or global scales. We propose four dimensions that are particularly relevant when valuing ecosystem services provided by UGS at the city or locality level: *(i)* the scale of the UGS; *(ii) the* objective of the valuation exercise; *(iii) the functionality and ubiquity of UGS; (iv) local* capabilities and resource constraints. We follow these criteria when selecting and presenting alternative valuation methodologies for ecosystem services provided by UGS.

This document follows the EPA definition of Urban Green Spaces: "... patches of land partially or completely covered by grass, trees, shrubs, or other vegetation". Green space includes parks, community gardens, as well as cemeteries, schoolyards, playgrounds, public seating areas, public plazas, and vacant lots that fulfill the abovementioned requirement (EPA, What is Open Space/Green Space?, N/A).[4]

[4] This document follows the EPA definition of Urban Green Spaces: "... patches of land partially or completely covered by grass, trees, shrubs, or other vegetation". Green space includes parks, community gardens, as well as cemeteries, schoolyards, playgrounds, public seating areas, public plazas, and vacant lots that fulfill the abovementioned requirement (EPA, What is Open Space/Green Space?, N/A).

Economic Assessment Framework for Health and Wellbeing Effects of Urban Green Spaces

Table 2.2

Four relevant dimensions to value UGS at the local scale

Dimension	Characteristic/constraint	Impact on cities
Scale	The scale of UGS can vary significantly, but for most cities usually can be thought of as small to medium sized patches of land, or even as a system of interconnected individual assets; i.e., local scale, instead of the traditional regional and global scales in which most studies focus. Scale not only matters for valuation, but also for operationalization and management (Byrne, Ambrey, Baker, & Matthews, 2016); (McPhearson, Hamstead, & Kremer, 2014).	Easier to implement ES mapping. Spatial concentration of most relevant social benefits—reduced cost of survey-based approaches. Scale may help define most relevant ecosystem services to value. Scale of benefits and cost may be small—difficult to prove their relevance for development based on small effects. May need to value systems of UGS rather than particular UGS.
Objective	Valuation of ecosystem services from UGS will likely be used for either (i) understanding the value of the cities' natural assets; (ii) urban planning and public investment; (iii) informing land development decisions. Some assessment objectives require more exhaustive valuation and understanding of ecosystem services (e.g., framing policy decisions), while other objectives may be met through the valuation of the most relevant services (e.g., comparing investment options for risk mitigation).	Methods applied should yield results relatively quickly. Participatory/inclusive identification and mapping of relevant ecosystem services is relatively easy and highly desirable. When representative samples cannot be drawn from the population, deliberative methods can be used to ensure political representation of diverse interest groups. Valuation should be pluralistic and—to the extent possible—holistic, but not necessarily exhaustive; should focus on most relevant ecosystem services provided the natural asset being valued.

(continued)

Economic Assessment Framework for Health and Wellbeing Effects of Urban Green Spaces

Dimension	Characteristic/constraint	Impact on cities
Functionality and ubiquity of UGS	Aside from its scale, the type of UGS (what is it used for?) and its location determine how people interact with it, and thus impacts on the 'relevance' and value of the ecosystem services provided by the UGS, at least as regards to use value (Czembrowski & Kronenberg, 2016).	Cookie cutter assessment frameworks will not provide accurate estimates of the UGS value, even for the same type of spaces or assets. Given the constraints on scale and type, the social value of green spaces and other natural assets at the urban scale is usually concentrated on a relatively small and homogenous set of ecosystem services (cultural, recreational, air purification, noise reduction, etc.) (Haase, et al., 2014). Even if there is no unique valuation framework, a relatively short set of methodologies can be tweaked to fit the specific scale, type, and location of the UGS. Ubiquity of UGS may difficult or preclude the use of certain valuation methods (i.e., travel cost).

(continued)

Economic Assessment Framework for Health and Wellbeing Effects of Urban Green Spaces

Local capabilities and resource constraints	Different valuation methods require different combinations of technical capabilities and knowledge. Some methods are data intensive and require primary and secondary sources of information, while others rely on structured deliberation or just make use of existing studies. The implementation of some methods will require multidisciplinary teams (e.g., ecologists, sociologists, economists), while for other methods, a more restricted set of skills may suffice. Of course, the difference in technical requirements may translate in significant differences in costs. Barton, Harrison, Sander, & Martin-López (2017) present factsheets for several economic valuation methods with descriptions of technical and resource requirements.	In the short term, cities should be mindful of capability, interdisciplinarity, and data and resource constraints when choosing valuation methods. Participatory non-monetary methods may have a large potential for ES valuation in cities strongly constraint by a lack of technical capabilities and data scarcity (Pandeya, et al., 2016). In the medium to long-term, focus on building strong multidisciplinary teams. Different ecosystem services require different methods, and different methods require different capacities. Thus, although teams should be flexible, cities may start by developing the capabilities most in demand given the set of natural assets and ecosystems services that may be valued in the future.

Source: own elaboration based on Barton, Harrison, Sander, & Martin-López (2017); Czembrowski & Kronenberg (2016); Byrne, Ambrey, Baker, & Matthews (2016)

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UGS can potentially provide multiple services to urban dwellers. However, due to the intrinsic characteristics of UGS and the constraints for its holistic valuation, the academic literature on urban ecosystem services has focused on a subset of ES that *(i)* will likely be provided by the asset or location; and *(ii)* if produced, will generate relatively large—or noticeable—benefits for the population. In terms of ecological ES, the literature has put significant attention on regulating and provisioning services, but less attention has been dedicated to valuing supporting and habitat services (Haase, et al., 2014). Moreover, cultural and recreational services are often an important component of ecosystem valuation at the urban scale, in part due to the existence of multiple, well established, methods for this type of valuation (e.g., stated preferences or contingent valuation), and partly because the relative weight of cultural and recreational ecosystem services to Total Economic Value is significant at the urban scale (see Xu, You, Li & Yu,2016; Bolund & Hunhammar,1999).

Valuation of Ecological Ecosystem Services Provided by UGS

No unique valuation approach can capture the diversity of ecological services provided by UGS. For instance, a suitable method to value seed dispersal services in urban gardens may not be useful to value pollution filtration in urban forests. Moreover, a holistic valuation of UGS for practical purposes requires analyzing them as bundles of services rather than in a standalone fashion; however, ambiguous Of course, UGS and green infrastructure not only provide services to society, they can also provide disservices (measured as social costs or losses for human well-being). Some disservices include view blockage, allergies, and damage to grey infrastructure. Gómez-Baggethun, et al. (2013) provides a comprehensive list of disservices and related studies. Other provisioning services that may or may not be traded in markets, such as freshwater supply, can be valued using an "opportunity cost approach"; i.e., the cost expected to be incurred in the absence of the UGS, or alternatively the cost of replacing the UGS by the next best solution. For instance, Thibodeau and Ostro (1981) estimate the value of wetlands in the Charles River Basin (Massachussets, USA) as the difference in the cost of obtaining water from wetland wells and the cost of providing water via the next best technical solution (as cited in Sundberg, 2004, p. 32). However, cost-based approaches tend to be applied mostly when valuing regulating ecosystem services. Non-market methods such as contingent valuation or hedonic pricing can be applied to value provisioning services of UGS (Netusil, Kincaid, & Chang, 2014; Jenerette, Marussich, & Newell, 2006). Provisioning services of UGS may not be significant in most cases, as scale limits its potential social benefits. This type of valuation is therefore more suited for urban forests or large scale parks.

[5] Of course, UGS and green infrastructure not only provide services to society, they can also provide disservices (measured as social costs or losses for human well-being). Some disservices include view blockage, allergies, and damage to grey infrastructure. Gómez-Baggethun, et al. (2013) provides a comprehensive list of disservices and related studies.

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UGS may provide significant regulating ecosystem services such as run-off mitigation, carbon sequestration, or buffering from extreme climate events. These services, both at the urban and global scale, are often valued using cost-based methods such as the damage cost avoided or replacement cost approaches (Emmanay, et al., 2011; Wang, Bakker, De Groot, & Wörtche, 2014). The benefit transfer approach can also be a viable option if (i) cities are constrained by availability of local data, or lack of technical and financial resources; or if (ii) cities are interested in valuing an aggregation of relatively standard natural assets—for instance, valuing regulating services of urban trees (Peper, et al., 2007).

Supporting ecosystem services are not often assessed at the local scale, partially due to the intricacies involved in valuating such services. In theory, relevant supporting ecosystem services at the local level such as pollination, pest control, and seed dispersal can be valuated using the production function and replacement cost approaches. Hougner, Colding, & Söderqvist (2006) apply both methods to value oak seed dispersal services in the Stockholm National Urban Park. However, these methods are information and skills intensive; they require large datasets of market prices, a deep understanding of the interdependence of local ecosystem services, and complex biophysical modelling capabilities (e.g., pollination dependency ratios). Thus, the valuation of these ecosystem services may be only feasible and worthwhile to a relatively small numer of cities around the world.

Likewise, UGS are thought to play an important role as habitat for biodiversity (Gómez-Baggethun, et al., 2013). As in the case of other supporting ecosystem services, habitat services at the urban level has not ben thoroughly addressed in the economic valuation literature. Some authors have opted for stated preference methods, contingent valuation, and benefit transfers in order to estimate the social value of habitat services. La Notte (2012) applies these methods to valuate habitat services in two locations in north-east Italy; yet, as the authors point out, these estimations rely heavily on biophysical and economic assumptions, and may not be robust enough to inform investment decisions and land-use planning.

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[6] *Arguably the most relevant regulating ecosystem services provided at the urban scale are temperature regulation, air purification, and noise buffering. These ecosystem services are closely related to human health and wellbeing and are therefore discussed in a following section of this document.*
[7] *See Robinson & Lundholm, (2012) and Gómez-Baggethun, et al. (2013).*

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Table 2.3

Ecological services delivered by UGS and relevant valuation methods

Type	Examples at urban level	Valuation methods					
		Market Prices	Cost based	Production Function	Revealed pref.	Stated pref.	Benefit transfer
Provisioning	Food supply in urban markets; freshwater supply in urban watershed	Preferred	Appropriate	Not relevant	Appropriate	Appropriate	Not relevant
Regulating	Temperature regulation; noise abatement; air purification; rainwater drainage; sewage treatment	Not relevant	Preferred	Not relevant	Appropriate	Not relevant	Appropriate
Supporting	Pollination; pest control; seed dispersal	Not relevant	Appropriate	Preferred	Not relevant	Not relevant	Not relevant
Habitat for biodiversity	Shelter for migratory birds	Not relevant	Not relevant	Not relevant	Appropriate	Preferred	Appropriate

Not relevant Appropriate Preferred

Source: own elaboration, based on Smith & Harrington (2014); Deutsch, Dyball, & Steffen (2013); Sundberg, (2004); Jenerette, Marussich, & Newell (2006); De Groot & Wörtche (2014); Hougner, Colding & Söderqvist (2006); La Notte (2012).

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Case Study 8: A spatial valuation of the natural and semi-natural open space areas in eThekwini municipality

In 2017, a study commissioned by the World Bank and co-funded by The Nature Conservancy presented one of the most comprehensive assessments of ecosystem services within an urban environment in Africa to date. The aim of this study was to provide estimates of the value of ecosystem services delivered by natural open space areas within the eThekwini Municipal Area (EMA) in South Africa. The EMA, which includes the city of Durban, covers an area of just less than 2,300 km2. The EMA is situated in the center of one of 34 Global Biodiversity Hotspots, the Maputaland-Pondoland Albany region, and contains an impressive array of biological diversity. While there is a sense among city managers that natural assets deliver valuable ecosystem services and will contribute to the city's resilience in the face of climate change, these arguments alone are not enough to sway decision-makers to preserve the remaining natural areas. An economic measure of ecosystem value could thus be a defining factor for conservation decision-making.

The study provided a monetary estimation of the Total Economic Value of these natural areas based on the economic valuation of the ecosystem services delivered by these assets. The authors identified 15 relevant ecosystem services in the EMA: 7 provisioning services (e.g., fuelwood and fishery resources), 6 regulating services (e.g., carbon storage and flow regulation), and 2 cultural services (tourism and amenity value).

Provisioning resources were quantified using sustainable yields for each resource and adjusted for habitat conditions and expected demand. Then, the authors applied the market price approach to value the social benefit provided by these ecosystem services. The estimated value of provisioning services was 97.9 million Rands (in 2015 value), 2.3% of the TEV of the EMA's natural areas.

Regulating services were valued through cost-based methodologies. For instance, carbon sequestration was valued using the avoided damage cost approach, i.e., the damage that would be produced if the carbon stored in all the major vegetation types of the EMA were liberated into the environment. Likewise, flow regulation, sediment retention, and water quality amelioration services were first quantified using hydrologic models and then valued using the replacement cost approach, ie., the capital costs of engineered solutions under the present versus the without-vegetation scenarios. The estimated value of regulating services was 87.1 million Rands (in 2015 value), 2.1% of the TEV of the EMA's natural areas.

(continued)

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Case Study 8: A spatial valuation of the natural and semi-natural open space areas in eThekwini municipality

Cultural services were valued using a mixed approach. Amenity value was estimated using the hedonic price method, i.e., the value associated with different types of green open space on property sale prices within the EMA. Moreover, tourism was quantified and ranked using geo-tagged photos on social media to evaluate people's preferences for locations and natural commodities within the EMA. Then, these locations and amenities were monetized using data on estimated expenditure of tourists visiting Durban. The estimated value of cultural services was 3,986.8 million Rands (in 2015 value), 95.6% of the TEV of the EMA's natural areas.

Source: adapted from (Turpie, Letley, Chyrstal, Corbella, & Stretch, 2017).

Valuation of Cultural and Recreational Ecosystem Services Provided by UGS

Cultural ecosystem services (CES) are "the non-material benefits people obtain from nature. They include recreation, aesthetic enjoyment, physical and mental health benefits and spiritual experiences" (IUCN, 2014, p. 1). CES are driven by human experience, either through direct or indirect use, and in some instances even through "non-use". CES promote the strengthening of social cohesion, create economic opportunities through ecotourism, generate aesthetic value for the community, and contribute to the creation of a 'sense of place'. In this sense, CES are strongly linked with human wellbeing. In fact, CES may be the most widely perceived and highly valued ecosystem service delivered by smaller scale UGS such as pocket parks or urban gardens (Camps-Calvet, Langemeyer, Calvet-Mir, & Gómez-Baggethun, 2016, p. 21).

Despite its importance, CES are often not valued at the local level. Practical valuations of CES delivered at the urban scale have lagged in comparison to valuations of regulating and provisioning services (Haase, et al., 2014, p. 417). Moreover, cultural ecosystem services are yet to be integrated into planning and operational frameworks at the local level. Paracchini, et al. (2014) notes that this lag in research and practical valuations of cultural ecosystem services is partially due to "... [the] transdisciplinarity [that] is required to address the issue, since by definition cultural services (encompassing physical, intellectual, spiritual interactions with biota) need to be analyzed from multiple perspectives (i.e. ecological, social, behavioral)".

Among the set of urban CES, recreational ecosystem services are a typology of services that receives significant attention in the academic literature and in practice; a literature review

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by Hernández-Morcillo, Plieninger, & Bieling (2013, p. 439) finds that more than 50 percent of indicators used in the literature to quantify and valuate CES were related to recreational ecosystem services.[8] The UN's Millennium Ecosystems Assessment framework describes recreational services as those that allow and promote the use of natural capital for leisure pursuits. Through recreational services communities can experience the benefits associated with experiential use of their natural environment (Clough, 2013). Moreover, recreational services are tightly linked to human health and wellbeing through activities such as open-air sports. Because of this, valuation of recreational services is at times done separately and through different methods than those used in other CES valuations (Hermes, et al., 2018). However it is important to ensure that potentially adverse health impacts to users are minimized or eliminated entirely when planning and building green spaces. In other words, community sports fields or parks should not be located in or adjacent to sources of pollution, such as major truck or car routes, polluting industrial zones shipping ports, or contaminated sites.

The economic valuation of the cultural and recreational ecosystem services delivered by UGS can be a challenging undertaking. On the one hand, CES are difficult to identify, quantify, and map. However, research in this area has increased substantially in recent years, providing practitioners with promising frameworks and tools for pluralistic identification and mapping (Balzan, 2018; Paracchini, et al., 2014; Pietrzyk-Kaszyńska, et al., 2017).

On the other hand, the quasi-public nature of most urban ecosystems imposes a significant challenge for valuating cultural and recreational ecosystem services; as Hermes, al. (2018) point out, "assigning monetary values to RES has been a challenge in RES evaluation, largely due to the lack of market surrogates that can approximate the prices associated with these non-excludable goods" (p.92).

Given these inherent challenges, how can cities value the cultural ecosystem services delivered by their UGS and other green infrastructures? The Economics of Ecosystems and Biodiversity framework document identifies a subset of cultural ecosystem services that are expressed in human action and can potentially be valuated through traditional monetary approaches; these include recreational services, cultural heritage, ecotourism, and environmental education (TEEB, 2010). Some researchers argue that cultural and recreational ecosystem services contribute directly to human interests and sense of value, and because of this, people do not require sophisticated ecological knowledge to assess and relate the value they obtain from intangible services such as aesthetic landscape quality. If this were indeed the case, stated preference methods would be particularly well suited for valuating these ecosystem services (Rewitzer, et al., 2017).

[8] The acronym RES stands for Recreational Ecosystem Services in the paper quoted.

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Among stated preference methods, contingent valuation has been widely used to assess CES both at the regional and global level. For instance, van Berkel & Verburg (2014) integrate participatory mapping, photo manipulation techniques, and traditional contingent valuation surveys to elicit the WTP from simulated changes—that would lead to changes in the delivery of CES—in an agricultural landscape in Achterhoek, the Netherlands. Likewise, Lo & Jim (2010) provide an example of a holistic monetary valuation of UGS using the contingent valuation approach. Choice experiments are an interesting alternative to contingent valuation, but still in the realm of stated preference approaches. These methods do not ask respondents to state their WTP for a natural asset or ecosystem services, but rather present diverse scenarios in which only one characteristic of the asset or site changes, in this case, a characteristic related to cultural and recreational value (see Appendix). Baulcomb, et al., (2015), Oleson, et al., (2015) and Rewitzer, et al., (2017) are all interesting examples of choice modelling for diverse types of CES—although none related to UGS.

Revealed preference is another often used approach to valuate CES. Revealed preference methods do not rely on respondents stating their WTP, but rather they useinformation of prices in surrogate markets—most often housing sale or rent prices and cost of travel estimations. Examples of hedonic prices valuations that exploit real estate market transactions data to value urban CES include Czembrowski & Kronenberg (2016) and Jim & Chen (2009).[9,10]

It is worth noting that hedonic prices rarely capture specific ecosystem services, but rather capture the value of a location or environmental amenities. Thus, its applicability for valuating CES delivered by UGS is limited. The travel cost method is frequently used to value CES at the global and regional scales, but not often at the local scale, as—in some cases—the ubiquity and location of UGS make the "cost of getting there" negligible, and thus not a good surrogate price to value ecosystem services. Nevertheless, interesting applications of the travel cost method to valuate UCS provided by UGS do exist; for instance, Hutcheson, Hoagland & Jin (2018) use this method to valuate environmental education in the Houdson River Park in New York City.[11]

Although the abovementioned methods have been applied with varying degrees of success to valuate urban CES such as ecotourism, recreation, environmental education, and landscape

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[9] See Chan, Satterfield, & Goldstein (2012) and Milcu, et al. (2013) fur further discussion and references.

[10] The literature review carried out by Milcu, et al. (2013) suggest that there may be some truth to this logic. As stated, preferences are by far the most common approach used among the studies that actually pursue a monetary valuation of CES. The authors suggest that "… the most frequently studied cultural ecosystem services…are the most easily quantifiable (e.g., Chan and Ruckelshaus 2010), further deepening the gap between counting that which matters to people and that which is easy to measure" (p. 7).

[11] However, the methodology applied by the authors is not directly applicable to CES; during the preparation of this whitepaper we did not come across a peer-reviewed study of monetary valuations of the CES provided by UGS.

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aesthetics, many other CES have "proven resistant to monetary valuation, as they do not conform well to economic assumptions, and their assessment is complicated by the properties of intangibility and incommensurability" (Hernández-Morcillo, Plieninger, & Bieling, 2013, p. 436). In particular, CES such as sense of place, identity, cultural heritage, spiritual, and psycological ecosystem services may not be easily—if at all—valued through conventional monetary methods. Even if they were, it is not clear that the value obtained would be meaningful (Scholte, Van Teeffelen & Verburg, 2015; Spangenberg & Settele, 2010).

Given these challenges inherent to monetary valuation, many authors increasingly employ socio-cultural methods to elicit non-economic values from CES. In fact, a literature review conducted by Hernández-Morcillo, Plieninger & Bieling (2013, p. 440) found that more than half of the studies reviewed relied on non-monetary indicators to quantify and value CES. Deliberative approaches such as Delphi surveys and the Q method (Milcu, et al., 2013, p. 8) and other socio-cultural methods such as time use studies, narrative assessments, participatory GIS mapping, or photo-elicitation, have been gaining popularity in the valuation literature (Barton, et al., 2017, pp. 213-254). Cities looking to value the CES delivered by UGS could find in socio-cultural methods a useful alternative. Socio-cultural techniques may better capture the relationship between a specific cultural service and its user (i.e., preferences, expectations, experiences), and thus can provide a pluralistic measure of value. Moreover, socio-cultural methods are often less demanding in terms of data, local capabilities, and financial resources. Nonetheless, values obtained through socio-cultural valuations may be difficult to integrate into planning and policymaking processes (see Appendix 1). (Balzan & Debono, 2018)

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Table 2.4

Cultural and recreational services delivered by UGS and valuation methods

Type	Examples at urban level	Valuation methods					
		Market Prices	Cost based	Production Function	Revealed pref.	Stated pref.	Non-monetary
Recreational	Sightseeing; birdwatching; open-air sports	Not relevant	Not relevant	Not relevant	Preferred	Appropriate	Appropriate
Cultural	With direct or surrogate markets: ecotourism; environmental education; cultural heritage	Not relevant	Not relevant	Not relevant	Preferred	Appropriate	Appropriate
	With no direct or surrogate markets: aesthetics; spiritual, psychological, symbolic	Not relevant	Not relevant	Not relevant	Not relevant	Appropriate	Preferred

Not relevant | Appropriate | Preferred

Source: own elaboration, based on (Balzan & Debono, 2018); Czembrowski & Kronenberg (2016); Jim & Chen (2009); Hernández-Morcillo, Plieninger & Bieling (2013); Milcu, et al. (2013); Barton, et al. (2017)

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Valuation Approaches for Health and Wellbeing Benefits of Urban Green Spaces

At the urban scale, ecosystems have great potential to provide significant benefits to society in the form of improved human health and wellbeing. In fact, recent research suggests that accessibility to UGS is correlated to reduced mortality rates and improved general health, both perceived and actual (Maas, et al., 2006). Moreover, research suggests that differences in accessibility to UGS among socio-economic groups are often linked to urban inequalities in terms of both physical and mental health (Bird, 2007, as cited on Elmqvist, et al., 2015, p.102).

In this context, some authors argue that UGS and other forms of natural infrastructure could present a cost-effective investment option to improve public health, enhance living conditions, and build resilience to climate change (MacKinnon, van Ham, Reilly, & Hopkins, 2019, p. 371). However, integrating UGS and other green infrastructures into the planning and policymaking processes of cities requires that bureaucrats and decision-makers fully grasp the benefits that their constituencies could reap from investments in nature conservation and greater access to green infrastructures. Producing monetary valuations and eliciting socio-cultural value from UGS is an important, although not sufficient, step in this direction.

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In section 2.2 we presented the most relevant ecosystem services delivered by UGS according to the academic literature and then discussed different methodologies that cities could use in valuing them. To some extent, all the urban ecosystem services discussed have a direct impact on human wellbeing and, arguably, most of them could influence human health outcomes. However, a growing body of literature on ecosystem services and human health and wellbeing in urban areas suggest four main social benefits of UGS and green urban infrastructures: *(i)* air purification; *(ii)* temperature regulation; *(iii)* noise buffering; *(iv)* physiological and psychological wellness (Tzoulas, et al., 2007; Salmond, et al., 2016; IUCN, 2017; Douglas, 2012; Lundberg & Åman, 2015).

How can cities valuate these urban ecosystem services?

Air purification

The vegetation in UGS can improve urban air quality by filtering particulate matter (PM10), nitrogen Dioxide (NO2), Sulphur dioxide (SO2), and other atmospheric particulates, which in turn can help reduce occurrences of respiratory and cardiovascular disease (see section 1). For valuation purposes, the urban ecosystem service of air purification can then be defined as the "lowering of background air pollution concentration" (Derkzen, van Teeffelen, & Verburg, 2015).

Although air purification ecosystem services delivered by UGS can be valuated through different methods, the most common approach in the literature is the use of specialized software that model urban forest structures and estimate the value and economic benefits of the vegetation. The most used tool in practice for valuating air purification is the "i-Tree"; as of 2018, the i-Tree tool had been applied in more than 130 countries (Raum, et al., 2019). An interesting example of urban tree valuations using the i-Tree tool include Nowak, Hirabayashi, Doyle, McGovern, & Pasher (2018), who follow a stepwise approach: on a first stage, the authors employ the i-Tree Eco model to estimate the removal of selected air pollutants in urban forests. On a second stage, they apply a set of 'national median externality values' to monetize the purification services in terms of human health outcomes (more precisely, in terms of avoidance of incidences of human mortality and incidences of accutte respiratory symptoms). For all its advantages, valuations based on urban tree modelling risk oversimplifying the heterogeneity of the UGS system (Derkzen, van Teeffelen, & Verburg, 2015).

Other valuation approaches may be suitable to monetize air purification ecosystem services at the urban scale. Stated preference methods such as contingent valuation and choice experiments can approximate the WTP of individuals to avoid losing a desired environmental attribute of UGS (in this case, 'air quality'). However, this method is a more suited value to ecosystem services and natural assets whose qualities can be easily observed by the respondent. Refer to Kwak, Yoo, & Kim (2001) and Giergiczny & Kronenberg (2014) for examples on revealed preference methods to valuate air quality ecosystem services at the urban scale.

[12] Externality values can be considered the estimated cost of pollution to society that is not accounted for in the market price of the goods or services that produced the pollution". (Nowak, Hirabayashi, Doyle, McGovern, & Pasher, 2018, p. 42).

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Revealed preferences methods such as hedonic prices could theoretically be employed to capture the social benefits from improved air quality through variations in rent and sale prices in the housing market (see Sander, Polasky & Haight, 2010). However, this method is more suited to valuate specific natural assets or locations (i.e., bundles of ecosystem services) rather than individual ecosystem services. Finally, the EPA's Guidelines for Preparing Economic Analyses discuss the monetization of air quality using avoided costs approach, in terms of human health, ecological, and aesthetic improvements. Methods related to this approach include the averting cost method, mitigation cost method, indirect cost method, and cost of illness method (EPA, 2010, pp. 7-9). Nevertheless, this approach is intensive in data, technical capacity and resources, and thus may be more suited to regional or global valuations performed by specialized institutions.

Temperature regulation

The vegetation in UGS provides shade and humidity, increasing evapotranspiration and both reducing surface and ambient temperatures. The trees in UGS also reduce heat storage by restricting solar heating of surfaces with high heat capacity and thermal conductivity, such as concrete (Salmond, et al., 2016). The temperature regulation services provided by UGS and urban trees can reduce the urban heat island effect, improve human thermal comfort and boost energy efficiency of nearby buildings (Elmqvist, et al., 2015).

Although the ecosystem service of temperature regulation is relatively well understood and amply studied in biophysical terms, its monetization—or even its non-monetary valuation—is not nearly as developed in the academic literature. Recently, specialized tools such as the i-Tree software and the CUFR Tree Carbon Calculator have allowed researchers to model changes in energy consumption in residential and commercial buildings resulting from increased shade areas of nearby trees. On a second stage, energy savings are estimated based on modeled consumption using a market prices approach (McPherson, et al., 2017; Pandit & Laband, 2010). Energy savings offer a lower bound monetary estimate of the temperature regulation services provided by UGS, but do not consider other relevant human wellbeing effects such as thermal comfort on public spaces.

These valuations are notoriously data and skill intensive, and thus may not be feasible for most valuation units at the local level. Additionally, the value generated by individual UGS may not be significant from a policymaking or planning point of view, and thus these approaches seem to be more suited for valuating larger-scale green infrastructure (e.g., urban forests or large urban parks).

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Noise reduction

Urban noise has been associated with stress, cardiovascular disease, self-reported sleep disorder, cognitive impairment, and productivity losses in the workplace (WHO, 2011). Trees and shrubs in UGS can provide a buffer against urban noise pollution (e.g., traffic noise roadside of busy streets), indirectly impacting human health and wellbeing. Aside from attenuation, UGS can play a role in masking anthropogenic noises with nature sounds, improving the quality of the soundscape for urban dwellers (Salmond, et al., 2016). Thus, for valuation purposes this urban ecosystem service can be defined as the "physical capacity of vegetation to attenuate environmental noise" (Derkzen, van Teeffelen, & Verburg, 2015, p. 1023).

While studies quantifying and mapping the noise reduction services of UGS abound in the literature (see for instance Derkzen, van Teeffelen, & Verburg, 2015; Fang & Ling, 2003), a final link to economic value, monetary or otherwise, is largely absent. However, existing methodologies to monetize the noise buffering provided by street trees could be employed, with minor tweaks, to valuate the noise reduction ecosystem services delivered by UGS (Donovan & Butry, 2011).

Because the ecosystem service of noise reduction provided by trees and shrubs is nonexcludable and nonrivalrous, observable market prices cannot be used to value it. Theoretically, cost-based approaches could be used to estimate the value of noise reduction services delivered by UGS. For instance, the replacement cost method could be employed to estimate how much would it cost to provide the same level of noise attenuation that UGS deliver via the most efficient grey infrastructure alternative; alternatively, the damage cost avoided method could be applied to estimate the economic costs arising from exposure to noise (e.g., lost productivity, cost of illness). However, in practice these methods are not commonly used (Łowicki & Piotrowska, 2015).

Alternative, and more popular, approaches include the hedonic pricing and contingent valuation methods. The hedonic pricing method can capture the effect of an attribute related to noise abatement (e.g., silence) on property prices and use this to estimate the WTP for noise reduction. However, this approach is more suited for environmental amenities than ecosystem services and is somewhat constrained by its data intensiveness. On the other hand, contingent valuation relies on self-reported willingness of people to pay for mitigating the negative effects of noise pollution on humans and the environment. The accuracy of this method depends heavily on the quality of the questionnaire and the sampling method, as WTP may be correlated with ability to pay (Andersson, Jonsson, & Ögren, 2013).

Bateman, Day, Lake, & Lovett (2001) discus strengths, limitations and constraints of using hedonic pricing to value noise reduction in urban settings.

[13] Bateman, Day, Lake, & Lovett (2001) discus strengths, limitations and constraints of using hedonic pricing to value noise reduction in urban settings

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Physiological and psychological wellness

Aside from air purification and noise attenuation, UGS can provide direct physiological and psychological benefits to their users. At the individual level, spending time in natural areas such as urban forests can contribute to improving mental health and lowering the risk of cardiovascular disease, obesity and asthma (Kondo, Fluehr, McKeon & Branas, 2018; van Ham & Klimmek, 2017; Douglas, 2012). At an aggregate level, UGS can improve public health in urban areas, helping local governments achieve substantial cost savings in delivering healthcare (MacKinnon, van Ham, Reilly, & Hopkins, 2019). Thus, for valuation purposes the human health ecosystem services provided by UGS may be defined as 'improvements on specific health outcomes attributable to the use of UGS", or alternatively as the "avoided morbidity and mortality directly arributable to the use of UGS".

The valuation of the human health benefits provided UGS and other green infrastructures at the urban level is a relatively new area of study and has been mostly focused on non-monetary values such as mortality rates, days of absenteeism, or counts of mental disorders treated in a specific area (Bowen and Lynch, 2017; Kondo, et al., 2018). Recently, a handfull of studies have managed to monetize the human health benefits associated with provision and increased access to UGS as "avoided costs of health care" due to reduction in mortality and morbidity (Greater London Authority, 2017; Varcoe, O'Shea, & Contreras, 2015; KPMG, 2012).

UGS can provide diverse human health benefits, derived both from direct and indirect use. Moreover, some human health benefits may be estimated using market prices (e.g. benefits from a decline in cardiovascular disease may be estimated using the average treatment cost for the disease), while others will require indirect methods (e.g., sense of wellness may be estimated through choice experiments). Thus, a holistic valuation of human health benefits delivered by UGS requires a multidisciplinary mixed methods approach.

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Table 2.5

Human health and wellbeing services delivered by UGS and valuation methods

Type	Examples at urban level	Valuation methods						
		Market Prices	Cost based	Cost of Illness	Revealed pref.	Stated pref.	Value transfer	Non-monetary
Regulation	Air purification	Not relevant	Preferred	Appropriate	Appropriate	Not relevant	Preferred	Not relevant
	Temperature regulation	Not relevant	Preferred	Appropriate	Appropriate	Appropriate	Preferred	Appropriate
	Noise reduction	Not relevant	Appropriate	Not relevant	Preferred	Appropriate	Appropriate	Appropriate
Physiological and psychological benefits	Improvements in mental health and lower the risk of cardiovascular disease, dementia, obesity and asthma. Improvements in cognitive development of children	Not relevant	Preferred	Preferred	Not relevant	Appropriate	Not relevant	Appropriate

Not relevant · Appropriate · Preferred

Source: own elaboration, based on Bowen and Lynch, 2017; Greater London Authority, 2017; Varcoe, O'Shea, & Contreras, 2015; KPMG, 2012.

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KPMG (2012, pp. 12-13) provides a useful framework to valuate these. Following this framework, cities could use cost-based methods (e.g., avoided damage cost, cost of illness) to estimate the savings in health care expenses due to a decrease in morbidity and mortality attributable to UGS. Aside from the quantification of the health-related ecosystem services, this method requires estimates for the average cost of treating the specific illnessess being impacted by UGS. This method is data intensive, but can employ readily available estimations of illness and cost of treatment at the national level (benefit transfer approach). Specific health-related services that do not have a surrogate market may be estimated using contingent valuation or choice experiment methods. Socio-cultural valuation methods could also be employed to approximate the value that citizens assign to the physical or psychological wellbeing they experience while using UGS.

A Starting Point for Integrated Valuations of Urban Green Spaces at the Municipal Level

If local governments are to incorporate the assessment of natural assets and green infrastructure into their economic toolbox, they must face the challenge that valuating complex systems with multiple functions, services, users, and types of use entails, while making sure that the result of this complex process can be used effectively to inform planning and policymaking. We propose a 7-steps approach to make it happen.

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Box B

A starting point for pluralistic economic valuation of UGS at the municipal level

Step 1: Define purpose and endpoints of the valuation

- Define purpose: natural capital accounting, conservation strategy, inform policy, compare public investment options.
- Define the natural assets and green infrastructures that will be valued (e.g., an aggregate of individual assets, such as urban trees; a green open space, such as an urban park; a natural asset, such as an urban forest; or a system of UGS).
- Identify available technical resources for the assessment (analysts and equipment). Alternatively, identify firms or experts with the required know-how.
- Define the timeframe and budget for implementing the assessment.
- Define the endpoints of the valuation (i.e., outputs of this process that will inform policy making and investment decisions).
- Establish decision criteria.

Step 2: Define the valuation scenario

- Identify status quo trends in ecosystems of selected UGS.
- Define policy alternatives (e.g., conservation vs development; investing in a new urban park vs a new sports center). Not all valuation approaches (or valuation objectives) require an alternative policy scenario.
- Define/simulate how policy alternatives impact identified UGS.
- Define the timeframe and scope of the valuation (e.g., neighborhood, municipality, metropolitan area, region).

(continued)

Economic Assessment Framework for Health and Wellbeing Effects of Urban Green Spaces

Step 3: Biophysical assessment

- Design and implement the biophysical assessment: map ecosystem structures in selected UGS and model ecosystem functions.
- Generate a comprehensive list of ecosystem services that may be provided by the selected UGS and correlate with the ecosystem functions modelled. Complement local biophysical assessment with academic literature, international cases, and experts' opinion.

Step 4: Identify and validate relevant ecosystem services and benefits

- Rank the preliminary list of ecosystems services according to their relevance at the scale of the assessment (e.g., municipality).
- Find main types of use for the most relevant ecosystem services identified.
- Identify the population that interacts (directly or indirectly) and the population that could be benefited by the provision of ecosystem services (non-use).
- Conduct workshops, focus groups, online surveys, or any suitable qualitative approach, to: (i) validate types of use; (ii) validate most relevant ecosystem services of selected UGS; (iii) identify other ecosystem services that may be important for the population; (iv) identify social benefits and costs (both private and external) for the selected ecosystem services and types of use; (v) elicit preferences and values of selected UGS for the population of interest. Aside from pluralistic, this step should aim to be representative.

Step 5: Quantify social benefits (and disservices)

- Quantify and map the supply of ecosystem services.
- Design or adapt benefit indicators for the list of relevant benefits. Indicators can be biophysical, social, or cultural, among other categories.
- Quantify the social benefits (and disservices) for relevant ecosystem services provided by UGS and types of use. If financial resources, time, or technical capabilities are a binding constraint, search for studies in similar contexts with similar scopes (see to Appendix 1, minimum criteria to apply value transfer approach).

(continued)

Economic Assessment Framework for Health and Wellbeing Effects of Urban Green Spaces

Step 6: Valuate and assess UGS

- Select appropriate valuation approach and method(s) based on identified ecosystem services and benefits, and based on local capability constraints, scale, objective, functionality, and ubiquity of UGS. Valuation may be monetary, socio-cultural, biophysical, or a mixed approach.
- Apply the selected methodology. Depending on the ecosystem services and benefits identified, valuation may require the application of multiple methods simultaneously.
- Because UGS provide more than one ecosystem service, it is important to consider the possibility of double counting benefits in the design phase of the assessment and redefine the approach accordingly.
- Valuation should aim to be pluralistic and representative. Design instances for people to interact and validate the valuation method or process. Participation is typically associated to socio-cultural (non-monetary) valuation approaches, but it should be an objective of any type of valuation. Participation will ensure that estimations reflect people's sense of value for UGS.
- Validate results of the valuation with the public. Community validation will increase the likelihood of successful integration of the valuation outputs into the planning and policy-making processes.
- Integrate the results of the valuation into the broader economic assessment framework (e.g., benefit-cost analysis or cost-effectiveness analysis). Follow decision criteria established in step 1.

Step 7: Integrate the output of the valuation and economic assessment of UGS into planning and policymaking

- Frame results of the assessment in terms that can be easily understandable and comparable with typical decision-making frameworks and tools.
- Craft messages in terms that can be understood by non-scientific public.

Source: own elaboration, based on (Barton, Harrison, Sander, & Martin-López, 2017, pp. 99-104)

Conclusions and Recommendations

Conclusions and Recommendations

Urban Green for Health and Wellbeing Contributes to More Resilient Cities

Green space planning has been promoted as an instrument to meet the social and ecological needs of cities. Its connection to health and wellbeing—although tacitly recognized—has not been easily included in the analytical and quantitative tools planners and city managers use. This is bound to change now. Cities are more than ever looking to be more resilient, considering the prevalence of climate risks, as well as the social and economic risks, and projecting the future of investments as sustainable and green.

Urban green space is becoming the key to better connect cities to natural ecosystems, foster biodiversity, address climate risks, and tackle a variety of needs related to health and wellbeing. However, the challenge remains to generate a larger definition of urban resilience, in which human health and wellbeing are intrinsic to the strategic vision of cities, so that they can better navigate future disasters and crises, and transit toward a more sustainable development path.

Policy recommendation 1
Addressed to: G20 leaders

Adopt a broader definition of urban resilience, in which health and wellbeing are intrinsic to the vision of cities, and urban green space is recognized as a key infrastructure to better connect the city to its natural environments, maximize the benefits from ecosystem services, foster biodiversity, address climate risks, and tackle a variety of needs related to health and wellbeing.

Conclusions and Recommendations

Leadership, Adaptive Planning, and Economic Assessment Tools Can Help Include Green Spaces in Urban Areas

Green urban projects take shape after a series of tradeoffs between stakeholders in the city. Local governments and other relevant actors often underestimate the value of green infrastructure, thus biasing decision-making toward single-use grey infrastructure projects. Cities would benefit from adopting more participatory and flexible methods to plan, such as adaptive planning, and integrating them into the traditional process-oriented methodologies. Adaptive planning relies on a trial and error approach, based on in-depth and multisectoral information gathering. This planning method is more suitable to the inclusion of green spaces to the always changing built structure of cities. An adaptive planning instrument goes hand in hand with an adaptive management approach; to be effective, these must be complemented with indicator-based monitoring.

Policy recommendation 2
Addressed to: local and subnational governments

Integrate a more participatory and flexible approach to planning, such as adaptive planning, to the more traditional process-oriented methodologies.

Following a more comprehensive understanding of what a resilient city should be, it is important that cities include criteria related to health and wellbeing in their planning and monitoring toolbox. Local governments are not systematically measuring health and wellbeing impacts attributable to green spaces and other green infrastructures. Although indicators related to air and noise pollution have been used by some high-capacity local governments, indicators related to cultural assets and human health are still greatly underutilized. To effectively operationalize indicators of health and wellbeing, it is necessary that cities invest in strengthening local capacity—both human and technological—including data gathering, modelling, and analysis. City networks can play an important role in deepening and socializing the understanding and applicability of appropriate indicators and methodologies.

Policy recommendation 3
Addressed to: local and subnational governments

Strengthen local human and technological capacity to design and operationalize M&E frameworks for the human health and wellbeing impacts of urban green space and other green infrastructures.

Conclusions and Recommendations

Valuation could greatly help the case for pursuing green urban projects by showing decision makers that nature-based solutions can provide cost-effective means to tackle urban challenges. However, decision-makers will not have incentives to invest in valuating natural assets if they do not know (or believe in) the potential of green and natural infrastructure. Thus, to break with this "chicken and egg" dynamic, it is essential to have champions—both inside and outside of government—advocating for valuating green infrastructures and natural assets at the local level, while supporting their claims with robust and relevant evidence. Platforms such as the U20 are in a privileged position to mainstream the potential of economic valuation of urban ecosystem services at the local level.

Policy recommendation 4
Addressed to: G20 leaders

Advocate the pluralistic economic and socio-cultural valuation of urban green space and natural assets at the local level, as a means for cities to fully understand the value of their natural assets and integrate them in planning and policy decision-making.

Capacity Building at the Local Level is Needed to Design, Create, and Maintain Urban Green

The review of quantification and valuation methodologies for urban ecosystem service—such as air purification, temperature regulation, noise attenuation, and psychological and physiological wellness—illustrates the importance of investing in flexible multisectoral teams and generating local capacity to produce and analyze data. Assessing urban ecosystem services requires a breadth of knowledge and skills that surpass the boundaries of any specific discipline. For instance, identifying, mapping, and quantifying the biophysical benefits delivered by urban trees may require trained ecologists, biologists, and other scientific professionals; identifying socio-cultural and psychologic services delivered by urban parks may require sociologists, public health professionals, or other specialists with background on qualitative research. Monetizing such ecosystem services may require the expertise of economists or other social scientists. In this context, the strengthening of local capabilities is instrumental in promoting the urban green agenda.

Valuation could greatly help the case for pursuing green urban projects by showing decision makers that nature-based solutions can provide cost-effective means to tackle urban challenges. However, decision-makers will not have incentives to invest in valuating natural assets if they do not know (or believe in) the potential of green

Conclusions and Recommendations

and natural infrastructure. Thus, to break with this “chicken and egg” dynamic, it is essential to have champions—both inside and outside of government—advocating for valuating green infrastructures and natural assets at the local level, while supporting their claims with robust and relevant evidence. Platforms such as the U20 are in a privileged position to mainstream the potential of economic valuation of urban ecosystem services at the local level.

Policy recommendation 5 **Addressed to: G20 leaders and local and subnational governments**
Establish transdisciplinary teams and invest in generating local capacity to produce and analyze data to assess ecosystem services, two main elements to promote an agenda of urban green and ensure appropriate valuation of urban ecosystem services.

Alongside technical capabilities, pluralistic and participatory valuation frameworks are essential to assess urban ecosystem services. The valuation methodologies based on ecosystem services are anthropocentric by definition and subjective by construction; only the most noticeable social benefits delivered by urban ecosystems are considered. But different communities may obtain different benefits trough different channels, and value them differently. Hence, including the voices and preferences of representative samples of beneficiaries of these services is critical, not only to value them appropriately, but also to give a political weight to conservation or investment decisions that may derive from these assessments.

Policy recommendation 6 **Addressed to: local and subnational governments**
Include the voices and preferences of the beneficiaries of ecosystem services in the valuation process, not only to value them appropriately, but also to give a political weight to conservation or green infrastructure projects.

Conclusions and Recommendations

Urban Green Space is an Essential Part of the Future of Resilient Cities.
If local governments are to incorporate the assessment of natural assets and green infrastructure into their economic toolbox, they must face the challenge that valuating complex systems with multiple functions, services, users and types of use entails, while making sure that the result of this complex process can be used effectively to inform planning and policymaking. We propose a 7-steps approach to make it happen.

Policy recommendation 7
Addressed to: G20 leaders and local and subnational governments

Establish a roadmap for implementing pluralistic economic valuations of urban green spaces, including:

- Define purpose and endpoints of the valuation
- Define the valuation scenario
- Biophysical assessment
- Identify and validate relevant ecosystem services and benefits
- Quantify social benefits (and disservices)
- Valuate and assess urban green spaces
- Integrate the output of the valuation and economic assessment of urban green space into planning and policymaking

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Appendices

Valuation Approaches and Methods for Ecosystem Services

Market Prices Approach

Pricing methods use observed market prices, either as direct measures of economic value of an ecosystem service (e.g., market prices) or as proxies for its value (e.g., cost-based approaches and production function approach).

The market price method estimates the economic value of services (and products) that are bought and sold in markets. Thus, the market price approach is especially suitable to value provisioning services such as timber, fibers or foods, for which specific markets exist. It is worth noting that the market prices approach, in its basic form, is limited to the estimation of direct use values of natural resources and ecosystem services. The standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using market price and quantity data[1] (King & Mazzotta, 2000). According to this method, the value of the ecosystem service (its total economic benefit) results from the sum of consumer and producer surpluses. Obidzinski et al. (2012); Spangenberg & Settele (2009); and Rist, Feintrenie, & Levang (2010) provide interesting examples of direct market price approaches to assess the social costs and benefits of oil palm plantations in Indonesia. The studies rely on market data to assess the economic gains of diverse stakeholder groups and compare them to other dimensions of interest (i.e., environmental impacts; soil degrading; etc.).

For the specific subset of natural resources and ecosystem services with well-defined markets, the market price approach is a convenient and cost-effective assessment tool, as data is inexpensive and relatively easy to obtaian. Also, the use of observed rather than inferred data of consumer preferences helps reduce the sources of bias during the estimation of social costs and benefits. However, the market price method is very limited, as not many ecosystem services are traded in markets; indeed, ecosystem services are generally thought of as public goods, and thus, even if available, market transactions may not reflect their real value to society (TEEB, 2010). Also, the market price approach to value ecosystem services may provide a lower-bound estimate, as it only captures one specific service or product, rather than the total value of a natural asset generated by a combination of services. Likewise, even in the case of products with well-defined markets, allocating the estimated value to a single ecosystem service

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[1] Consumer surplus is measured by the maximum amount that people are willing to pay for a good, minus what they actually pay. To estimate consumer surplus, the demand function for the service or product must be estimated, which requires data on the quantity demanded at different prices, as well as data on other factors that might affect demand. On the other hand, producer surplus is measured by the difference between the total revenues earned from a good, and the total variable costs of producing it. The estimation of producer surplus requires data on variable costs of production and revenues received from the good or service provided.

[2] King & Mazzotta (2000) point out that because cost-based methods use costs to estimate benefits "they do not provide a technically correct measure of economic value, which is properly measured by the maximum amount of money or other goods that a person is willing to give up to have a particular good, less the actual cost of the good. Instead, they assume that the costs of avoiding damages or replacing natural assets or their services provide useful estimates of the value of these assets or services".

may be conceptually flawed (and a potential source of bias), as these products tend to be co-produced by several services (Spangenberg & Settele, 2010).

Cost-Based Approaches

Cost-based approaches are centered on estimations of the costs related to the provision (or lack thereof) of an ecosystem service. The TEEB framework document "Ecological and Economic Foundations" defines cost-based approaches as those based on the costs "that would be incurred if ecosystem service benefits needed to be recreated through artificial means" (TEEB, 2010). Spangenberg & Settele (2010) include to this definition the "avoided damage cost" provided by an ecosystem service as a proxy for its value. It is worth noting that cost-based methods do not strictly measure utility (as they do not rely on the estimation of a demand curve), and therefore do not provide a measure of Total Economic Value[1] for ecosystem services, unlike revealed or stated preferences methods. Cost-based approaches tend to be restricted to specific ecosystem services (flood control) and are usually simpler and least costly than other valuation methods. We have identified three main cost-based valuation methodologies in the literature: (i) the replacement cost method; (ii) the damage cost avoided method; and (iii) the mitigation/restoration cost method.

The replacement cost method also called "cost of alternatives" considers the cost of providing a substitute good, usually an engineered solution, that would perform a similar function to an environmental good or ecosystem service. For instance, if flood protection is a significant ecosystem service provided by a wetland, the cost of an engineered solution to floods would represent a lower bound estimation of the social value of that wetland. In this sense, the replacement cost method can be a convenient approach to valuing ecosystem services, given that estimating the cost of gray infrastructure is a relatively simple task. However, the replacement cost method will only provide a valid estimate of the value of a specific ecosystem service if "the man-made alternatives are equivalent in quantity and magnitude to the natural functions; the alternative is the least-cost alternative method of performing the function; and individuals in aggregate would be willing to incur these costs to obtain the services" (Defra, 2007). Although these information restrictions are difficult to meet, (Nunes & Van den Bergh, 2001) and thus value estimates may be severely biased, the replacement cost method is widely used in practice. Some relevant examples include the valuation of the Catskill watershed in New York City (Elliman & Berry, 2007) and the valuation of ecosystem services provided by UGS in Jaipur (India) related to the reduction of surface run-off and replenishment of ground water during monsoon (Singh, Pandey, & Chaudhry, 2010).

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3 A forthcoming white paper from the IDB draws from the experience of 12 Latin American and Caribbean assessing nature-based solutions through the damage cost avoided approach, among other methods (IDB & UNEP, 2020, forthcoming).

4 Mitigation/restoration approaches, just as any other cost-based approach, will not provide a measure of welfare, as these methods do not deal with utility, and many factors aside from efficiency could sway the decision to maintain the provision of an ecosystem service. Barton, Harrison, Sander, & Martin López (2017) point out that "costs of actions do not necessarily equal the welfare effects of impacts. The assumption is that if actions have been undertaken their costs are less than the expected damages to ecosystem services. In practice, actual avoidance, mitigation, restoration, compensation costs incurred may be inflated by ineffective actions. The cost of actions depends on the regulatory standards for environmental liability in the particular jurisdiction of the project".

The damage cost avoided method, follows a similar logic to the replacement cost approach, but in this case, it estimates the value of avoiding damages due to lost ecosystem services. To do this, the method typically relies on the value of property protected by the ecosystem service, or the cost of actions taken to avoid damages in the absence of the service, as a measure of the benefits provided by a natural asset or an ecosystem service (Daly Hassen, 2016). Logically, this method is well suited to value natural assets, green infrastructures, and ecosystem services that contribute to risk mitigation; however, results are a lower bound estimation and should be complemented with other valuation tools in order to capture the co-benefits of the natural asset. For instance, if a coral reef protects adjacent property from coastal erosion and flooding, these risk mitigation benefits may be estimated by the damages avoided in the absence of the service or by the expenditures property owners would have to make to protect their property (IDB, 2020). However, co-benefits of the coral reef, such as habitat for biodiversity, tourism, recreation, fishing (provisioning) are not considered by this cost-based method and should be assessed separately.

The mitigation/restoration cost method refers to the cost of mitigating the effects caused by to the loss of ecosystem services or the cost of getting those services restored (TEEB, 2010). This approach follows a similar logic to the damage cost avoided method; in this case, the hypothetical cost of sustaining an ecosystem service must at least equal to the value of the most efficient technical solutions to mitigate the damages that could occur in its absence (if not, the engineered alternative would provide greater welfare gains than sustaining the ecosystem service). In turn, this value is taken as a lower-bound estimation of the value of the ecosystem services under analysis. The report "Integrated assessment and valuation of ecosystem services" prepared by the Openness Project includes a set of guidelines to perform mitigation cost-based valuations, as well as a discussion of potential drawbacks of the method (Barton, Harrison, Sander, & Martin-López, 2017).

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[5] If information is not complete—and thus, markets are not perfectly competitive—property prices may not reflect all available information regarding the social benefits provided by ecosystem services. Thus, the value that results from applying the revealed preferences method could be biased. Another common source of bias in revealed preferences methods are omitted variable bias (failing to control for attributes that may affect the asset's price). However, this can be partially addressed through spatial fixed effects (Abbott & Klaiber, 2011).

Production Function Approach

As discussed in section 2.1, ecosystems can generate value for society through services that cannot be directly measured, like the protection or support of other activities that do have directly measurable values. Given that these services could enhance the productivity of economic activities that have well defined markets, Barbier (2007) suggests that “one possible method of measuring the aggregate willingness to pay for such services is to estimate their value as if they were a factor input in these productive activities”.

The production function approach requires a marketed good or service that is produced with a mix of human-made inputs and ecosystem services. To apply this method, the analyst must first determine how a change in the selected ecosystem services (an input) affects the prices or quantities of the marketed product (the output), while accounting for changes in all other inputs. Then, the change in consumer and producer surplus before and after the change in the provision of the service is calculated. This difference is assumed to be the willingness to pay for the change in the ecosystem services. The report “Integrated assessment and valuation of ecosystem services” includes a set of guidelines to perform production function valuations, (Barton, Harrison, Sander, & Martin-López, 2017).

One of the most notable examples of the economic assessment of ecosystem services through the production function approach is the valuation of pollination services. Using the production function lens, pollination is taken as an input for the production of certain crops, and thus pollination services can be valued through the contribution of honeybees (or other vectors) to the productivity of pollination-dependent crops, as measured by market prices and quantities transacted. Swinton et al. (2007), Hanley et al. (2015) and Ricketts (2004) provide interesting examples of the valuation of pollination services at the global and local scales, respectively.

The production function approach is well suited to assess the indirect use value of ecosystem services. It is a methodologically solid method that provides consistent results. Perhaps the most relevant technical challenge for applying the production function method is that it requires data on the ecosystem services (usually regulating and provisioning) and on the relationship between the ecosystem services and the other productive inputs, which is usually difficult to obtain. The method also requires significant modelling capabilities that may not be available (or be prohibitively expensive) for low-capacity or data constraint actors. These informational constraints limit the usefulness of the production function method as a valuation tool for a very specific set of natural assets or ecosystem services.

Revealed Preferences Approach

When environmental goods and ecosystem services have no clearly defined markets, their value can be ascertained through related (or surrogate) markets. Revealed preferences methods exploit the fact that individuals factor in natural amenities and ecosystem services in their decision to purchase goods and services which include environmental attributes (Nijkamp, Vindigni, & Nunes, 2008). Revealed preferences are indirect valuation methods, analyst do not observe the value consumers place on the attribute of interest, rather this value must be inferred from market transactions (Peterson, 2003). Although revealed preferences methods can capture non-use values (such as existence value), these techniques perform better and are mostly employed to assess use value (Spangenberg & Settele, 2010). The two most widely used revealed preferences methods are the hedonic prices and travel cost techniques.

Hedonic Prices Method

The hedonic prices method examines the prices individuals pay for goods that feature an environmental component of interest. The analyst must estimate the price premium associated specifically to the provision of an amenity or service of interest (or, more frequently, bundles of services), while controlling for all other factors that may affect the asset price. In a perfectly competitive market, the change in price is then used as a proxy for the willingness to pay of individuals for an ecosystem service or environmental amenity. In practice, the most common application of hedonic valuations of ecosystem services involve housing markets. Housing markets are well suited for valuing environmental amenities and ecosystem services because the choice of housing location is often related to the provision of ecosystem services. Thus, home locations and sales prices reveal the implicit choice consumers make regarding the ecosystem service of interest (Peterson, 2003).

If information is not complete—and thus, markets are not perfectly competitive—property prices may not reflect all available information regarding the social benefits provided by ecosystem services. Thus, the value that results from applying the revealed preferences method could be biased. Another common source of bias in revealed preferences methods are omitted variable bias (failing to control for attributes that may affect the asset's price). However, this can be partially addressed through spatial fixed effects (Abbott & Klaiber, 2011).

Hedonic pricing is a solid and consistent method for valuing natural amenities and ecosystem services. It draws on existing data (housing prices and characteristics, neighborhood characteristics) and is not restricted to the valuation of very specific ecosystem services. Barton, Harrison, Sander, & Martin López (2017) argue that one of the most notable advantages of hedonic pricing is its capacity for awarness raising, as it can "... demonstrate to individual property owners the increase in private market values of public goods from green infrastructure amenities...aggregating values across all properties in the neighborhood of a green space can show l3arge total values, which may compete with real estate values of developing the green space" (p. 285). However, the method has significant drawbacks. It usually cannot differentiate between ecosystem services, rather it is applied to bundles of services provided by a specific environmental assets or green infrastructure. The method is data intensive and requires significant modelling capabilities, so it may be difficult to implement for low-capacity or data constraint actors.

Travel Cost Method

Travel cost valuation is a survey-based technique that builds upon the assumption that individuals will only travel to a certain place if the services obtained during the visit provide more utility than abstaining from the visit, hence dedicating the time to an alternative activity and saving the cost of travel. Under this logic, the cost of travel can be used to reveal the value of what has been enjoyed at the site—biodiversity, ecosystem services, complementary goods and services (Spangenberg & Settele, 2010).

As suggested by Barton, Harrison, Sander, & Martin López (2017), travel cost valuation is appropriate for eliciting socio-cultural and anthropocentric values linked to natural sites. In the context of ecosystem services, the travel cost method is restricted to direct use value from cultural and recreational services. However, this method is not suitable for estimating ecological value, such as that provided by supporting and regulating services. Moreover, travel cost valuation cannot be used to elicit indirect use value or non-use value (p. 282).

This method is widely used in practice, on its own, or as a complement to other valuation approaches (as it will be discussed in section 2.2, the travel cost method may be a particularly useful tool for the valuation of UGS). The method uses revealed data, avoiding common biases often present when using stated preferences methods, and provides an easy to understand measure of value. On the other hand, the travel cost method is data intensive—usually, the implementation of a travel cost valuation requires data on transport costs, entry fees, number/length of trips and the opportunity cost of time. It also requires data on the site's quality, size, location, accessibility, amenities (Boyd, 2012) and requires significant modelling capabilities. Aside from these regular drawbacks of revealed preference methods, an important challenge when applying the travel cost method is estimating the opportunity cost of time. The analyst must make assumptions about alternative uses of time for respondents (if they decided not to go to the site) and assign a monetary value to it, generally through a share of the hourly wage of the respondent. Such assumptions are often difficult to validate empirically (Barton, Harrison, Sander, & Martin López, 2017, p. 282) and usually not based on evidence (Czajkowski, Giergiczny, Kronenberg, & Englin, 2019)

Contingent valuations methods present respondents with a base scenario and a detailed description of an environmental change, then elicit value directly by asking respondents for their WTP to preserve the natural asset, service, or location (e.g., how much would you be willing to pay to preserve an urban park rather than allowing the development of a housing complex). The main challenge facing contingent valuation is ensuring realistic WTP estimations—that respondents' hypothetical WTP for preserving a natural asset conforms to what they would pay for it in the real world (Barton, Harrison, Sander, & Martin-López, 2017).

Choice experiments and conjoint analysis valuations aim at establishing the structure of preferences across multi-attribute alternatives. Instead of stating willingness to pay directly, respondents are provided with a set of alternatives related to the environmental asset or site, each with differing levels of ecosystem services and differing costs. Some of these attributes may be non-monetary (spiritual, social, cultural), but at least one must be monetary. Respondents are then asked to

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[6] Alternatively, respondents may be asked for their willingness to accept (WTA) for an environmental change, that is, how much should the government pay them to accept the change. Theoretically, both approaches should yield the same result, but in practice this is not the case. Some authors argue that the differences may be related to loss aversion (Spangenberg & Settele, 2010).

[7] Although both methods share theoretical and practical attributes, they are not the same. In fact, more recently the literature has favored choice modelling over conjoint analyses, as the latter are not always consistent with economic theory (Louviere, Flynn, & Carson, 2010).

[8] Their results suggest the equivalence of both methods (i.e., the two methods provide statistically convergent WTP estimates for total value and independent attributes).

rank and choose their favored option. The trade-offs that respondents make indirectly reveal their WTP for a change in environmental attributes or ecosystem services (Brander, et al., 2010).

Theoretically, choice experiments and contingent valuation can capture all elements of Total Economic Value, so these methods are widely used in the ecosystem valuation literature. Brey et al. (as cited in Spangenberg & Settele, 2010) apply the contingent valuation method to estimate the value of afforestation areas in northern Spain; (Chaikaew, 2017) designed and applied choice experiments to estimate the value of the carbon sequestration, agricultural productivity and nutrient control services provided by the Suwannee River in Florida; (He, Dupras, & Poder, 2017) apply both contingent valuation and choice experiment methods to estimate the value of ecosystem services generated by wetlands in southern Quebec.

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Benefit Transfer Method

The benefit transfer method projects benefits and social costs from one place and time to another place, time, or policy context. Boyle & Parmeter (2017) describe this method as the use or transfer of an estimated value, based on one or more original studies (study sites), to support a new policy decision (referred to as the policy site). Benefit transfers may provide an interesting valuation framework for local governments. The method can be applied to a wide variety of settings, as long as there are empirical studies on similar policy, social and biophysical contexts. Also, benefit transfers can be cost effective and require relatively fewer local capabilities; using previous studies, analysts construct a transferred value for the desired ecosystem service, instead of incurring in the costs of identification, mapping, estimation, and validation.

However, benefit transfers also face significant challenges, chief among them is the lack of correspondence between study and policy sites. On the one hand, existing value estimates from policy sites will rarely match perfectly with the mix of ecosystem services, natural assets, and policies at the study site (Plummer, 2009). Moreover, as Boyle & Parmeter (2017) point out, “the units of measurement may not be reported consistently across studies or in units that match the units

[9] From this point on, the terms socio-cultural and non-monetary valuation will be used interchangeably in this paper. In practice, socio-cultural valuation represents just one of many non-monetary valuation approaches (e.g., biophysical methods, multicriteria analysis, scenario planning) (Barton, Harrison, Sander, & Martin-López, 2017).

[10] The Openness Project report “Integrated assessment and valuation of ecosystem services” discusses most of these methods, their applicability and limitations, and provides useful references for further reading. (Barton, Harrison, Sander, & Martin-López, 2017, pp. 219-259).

needed at the policy site". For a benefit transfer to be valid as a valuation tool, it must at least meet the following conditions: (i) similarity between the biophysical conditions at the study and policy sites; (ii) similarity between the scale of the change in the natural asset or environmental amenity at the study and policy sites; (iii) similarity between the socioeconomic characteristics of the populations at the policy study sites; (iv) similarity between the setting in which the valuation was conducted at the and at the policy site (Bennett, 2006). It is important to note that, even if valid, a benefit transfer will provide an approximation of the benefits and social costs that are to be expected in the study site. (Perino, Andrews, Kontoleon, & Bateman, 2014), (Liu, Costanza, Troy, D'Aagostino, & Mates, 2010), and (Turpie, Letley, Chyrstal, Corbella, & Stretch, 2017) provide interesting examples of benefit transfers in the context of urban ecosystems in Britain, the US, and South Africa, respectively.

Socio-cultural and Other Non-monetary Valuation Approaches

Monetary valuation is an inherently incomplete and subjective process. Generally, analysts cannot identify and estimate all possible services provided by an ecosystem. Moreover, value estimates are built upon a series of often questionable hypotheticals and tend to be context and method dependent (i.e., the value of a specific ecosystem service may vary significantly when estimated through different methods).

Therefore, some ecological economists call for careful use of monetary methods, favoring the use socio-cultural approaches instead (Common, 2007a; Spash and Vatn, 2006; Vatn and Bromley, 1994; O'Neill, 1997b – as cited in Spangenberg & Settele, 2010, p. 334).

Among non-monetary valuation approaches, socio-cultural methods present a useful alternative to conventional monetary valuation at the local level. These methods examine the preferences, values, needs, and demands expressed by people towards environmental assets and ecosystem services through measures other than money (Chan, Satterfield, & Goldstein, 2012). The role of socio-cultural methods has been acknowledged and included in the valuation frameworks developed by the Millennium Ecosystem Assessment, The Economics of Ecosystem and Biodiversity, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, and the EU's Openness Project (Kelemen, García-Llorente, Pataki, Martín-López, & Gómez-Baggethun, 2014).

Socio-cultural valuation encompasses both qualitative and quantitative methods such as surveys, focus groups, citizen juries, demand mapping and time use studies, and deliberative methods. Within socio-cultural methods, a valuation paradigm that has gained significant traction recently is deliberative valuation; deliberative methods promote open, semi-structured dialogues between stakeholders and the public, aiming to 'aggregate' preferences regarding natural assets and articulate them in a cohesive manner. Deliberative methods can be based on utilitarian concepts (as monetary valuation is), but usually seek to elicit value from ethical beliefs, social norms, cultural, and psychological appreciations of nature. Deliberative methods can be particularly useful when assessing use or non-use values of ecosystem services is not feasible through monetary approaches (e.g., sense of place value or spiritual value), or when collective or intersubjective values are greater than the sum of individual values (Kenter, et al., 2016). Therefore, this framework can be particularly helpful when assessing cultural ecosystem services (Barton, Harrison, Sander, & Martin-López, 2017). Specific deliberative techniques include, but are not limited to, valuation workshops, citizens' juries, public forums for consensus building, and discourse-based valuations (Wegner & Pascual, 2011; Wilson & Howarth, 2002).

Yet, socio-cultural valuation of ecosystem services is not a formal methodological field with systematized and comparable procedures and indicators. As pointed out by Kelemen et al. (2014), non-monetary valuation "produces results whose accuracy and reliability is hard to judge or difficult to operationalize. To increase the applicability of [non-monetary valuation] it is necessary to clarify the boundaries and the terminology of the field, and address considerations with regard to the context-specificity of non-monetary techniques" (p. 1). The issue of operationalization is particularly important, as results derived from non-monetary valuations cannot be easily employed by policymakers to compare investment or policy options (i.e., little or no compatibility between traditional benefit cost analyses or cost effectiveness analyses and the outputs produced by socio-cultural valuations).

Recognizing the trade-offs and methodological pitfalls of both monetary and non-monetary valuation methods, an increasing number of authors advocate for a pluralistic approach to valuing ecosystem services that integrates both monetary and socio-cultural techniques. This holistic approach should promote greater public participation in the identification and mapping of services, and integrate a broader set of social preferences and perspectives to traditional monetary techniques based on the aggregation of individuals' willingness to pay (refer to: Chan et al., 2012a,b; Kumar and Kumar, 2008; Norton and Noonan, 2007; Munda, 2004; and Spangenberg and Settele, 2010; as cited in Scholte, Van Teeffelen, & Verburg, 2015). Delibertive Monetary Valuations (DMV) are a good example of an integrated approach to assessing ecosystem services. DMVs combine the deliberative approach to aggregating preferences, non-economic, and ethical values, thus generating a pluralistic understanding of the ecosystem services and their social value with the utilitarian underpinnings of conventional monetary methods, producing standard willigness to pay estimates for changes in service provision (Bunse, Rendon, & Luque, 2015).

Bunse, Rendon, & Luque (2015) summarize the DMV protocol implemented by MacMillan et al. (2002) in the first application of the DMV approach to ecosystem services valuation: "...proposed market stalls, also evolved out of the application of citizen juries in environmental decision-making. The market stall approach involves between five and twelve participants attending two meetings. The meetings involve presenting relevant information about the proposed project,

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