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Accounting for Natural Capital in Cities: Making the Invisible Visible

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1. INTRODUCTION AND CONTEXT

Although the consequences of environmental degradation have been the concern of ecologists and environmental scientists for decades (Arrow et al. 1995), measuring the extent of it has only come into focus recently for governments. This is based on the realisation that many goods and services fundamental to our society and economy depend on biodiversity and the natural environment (Millennium Ecosystem Assessment, 2005).

Integrating natural capital assets into national accounting systems was first introduced to be used in tandem with the UN sustainable development goals (SDG) beginning in 2010 (EU, 2019). Natural capital's objective was to be used for increasing afforestation and reforestation globally to meet SDG targets (Markandya, 2020). This led to a range of initiatives around how to use natural capital accounting, such as the 'natural capital declaration' (NCD) that was launched at the Rio+20 summit held in Brazil where governments pledged to monitor the unsustainable stress currently put on ecosystems by the economic activity they manage.

This enabled the global financial sector to work with organisations to develop tools and metrics to integrate natural capital factors into existing business and financial structures. In summary, its key aims were to: 1) Increase understanding of business dependency on natural capital assets; 2) Support development of tools to integrate natural capital considerations into the decision-making process of all financial products and services; and 3) Help build a global consensus on integrating natural capital into private sector accounting and decision-making. Such international agreed protocols around the accounting of natural capital sparked national government interest in understanding how changes in natural capital assets will impact humans and the economy (UN, 2012).

In the UK context, historic strides towards using natural capital in decision-making plans started to emerge in 2011 with the introduction of the National Ecosystem Assessment (UKNEA, 2014) in attempts to halt the decline of natural capital. A White Paper was produced with the stated intention to 'put natural capital at the centre of economic thinking and at the heart of the way we measure economic progress nationally.' An economic evaluation assessment found that nature is worth billions of pounds to the UK economy. Some examples include: the benefits that inland wetlands bring to water quality are worth up to £1.5 billion per year to the UK, and pollinators are worth £430 million per year to British agriculture (DEFRA, 2011).

These findings led to the formation of new working groups to develop natural capital accounts and provide advice on how to protect and restore nature and ecosystems. In England, the Natural Capital Committee (NCC) was created to advise on the work in developing natural capital accounting, both at the national and corporate levels. Other countries in the UK are taking different approaches, for example with the development of a Natural Capital Asset Index for Scotland and the creation of an integrated body, Natural Resources Wales, in Wales. Elsewhere, countries are developing approaches to natural capital accounting, including ecosystem mapping in Europe (Maes et al., 2013), and accounting frameworks being developed by the UN Statistical Division System for Experimental Ecosystem Accounting (SEEA) (United Nations Statistical Division, 2013).

The UK's Natural Capital Committee (NCC), from their work, has noted that many of the UK's natural capital assets are at risk or very high risk, and this is likely to worsen due to the changing effects of climate (NCC, 2014). As the extent of the changes grows, the costs are becoming increasingly apparent: from water shortages to flooding and coastal erosion, declining soil quality and pollinator abundance, which affect arable agriculture, and increasing healthcare costs associated with declining air quality. Ongoing trends and the future state of natural capital assets could therefore have potentially significant impacts on the growth of the UK economy. The UK also depends on stocks of natural capital elsewhere in the world through international trade and supply chains, exposing the economy to further risks from natural capital depletion beyond the UK. The most recent Climate Change Risk Assessment in the UK identifies specific risks to crop and fisheries, river and lakes, and the viability of coastal defences, in the coming years.

This Working Paper is a summary of findings from a NERC-funded project Discipline-Hopping for Environmental Solutions through the Climate Futures Network at the University of Liverpool. Through interviews and focus groups with thirteen finance and economics experts in natural capital accounting across the UK, Europe and North America, this paper is intended as a resource for local policymakers who are using or would like to use natural capital assessments in their green recovery or sustainability agenda. It provides a summary of why governments should pursue natural capital assessments, barriers in doing so, and ways to improve the use of natural capital for local governments.

2. WHAT IS NATURAL CAPITAL?

Natural capital is a broad term that includes many different components of the living and non-living natural environment, as well as the processes and functions that link these components and sustain life (NCC, 2019) (see Figure 1). There are three overall features that make up natural capital: stocks, ecosystem services and human benefits. Natural capital stock or 'assets' in a region is typically characterised by common ecosystem land cover types such as water, forests, wetlands, and grasslands, other biodiversity, such as also air, soil, and the assemblage of flora and fauna that make up these ecosystems (NatureScot, 2021).

Natural capital assets support the ecosystem services that underpin our economy and thus deliver inputs or indirect benefits to business (Guerry et al, 2015). These 'ecosystem services' can be drinking water, energy, or plant and fibre growth, from which people derive societal benefits (Mace and Bateman, 2020). Ecosystem services are the flow of benefits which people gain from natural ecosystems and natural capital is the stock (or wealth) of natural ecosystems from which these benefits flow (Eftcc, St. Helena, 2018). Since 2008, there has been an evolution in how ecosystem services are defined and categorised. The Economics of Ecosystems and Biodiversity (TEEB) reports propose the following framework for categorising ecosystem services (TEEB, 2010):

Provisioning: Food production and water; what can be directly useful/consumed by people.

Regulating: Services like air pollution removal, carbon sequestration, water filtration by wetlands, crop pollination by insects. What can be considered as indirect benefit from nature that is generated through the regulation of ecosystem processes (e.g. mitigation of climate change).

Cultural: These are considered non material benefits from nature (such as spiritual, aesthetic, and recreational). In urban environments, often this can be tourism and recreation, or giving residents and visitors a sense of place and well-being.

Supporting: This refers to specific ecological characteristics that in one way or another underpin the output of a 'final' ecosystem service (e.g. soil formation, photosynthesis and nutrient cycling).

Figure 1

Natural Capital

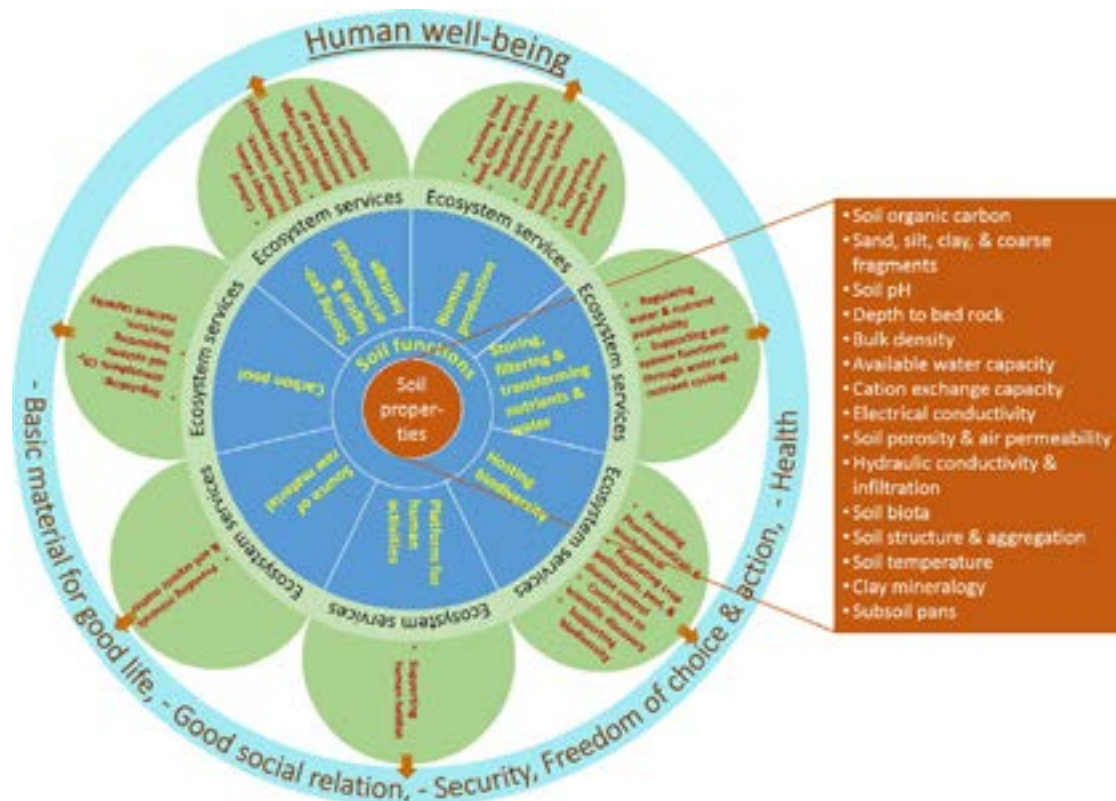


As in economics, an asset simply describes something that generates value (Bishop, 2004). For example, forests are natural capital assets which support ecosystem services including climate regulation and timber (TEEB, 2010). Take for example the natural capital stock of soil. There are a range of ecosystem services that flow from soil properties, such as hosting biodiversity, biomass production, being used for raw materials, and ability to transform nutrients. All of which then contribute to direct and indirect human benefits, such as pest disease control, regulating water, providing food, feed, fibre wood that underpins agriculture, regulating carbon sequestration and many more (see Figure 2). In significant ways, natural capital assets function in a way that underpins our entire economy.

use and the application of other sorts of capital. In terms of planning and development, natural capital mapping and accounting is being used to compare baseline and masterplan scenarios of developments to see the net gain in biodiversity and ecosystem service benefits that could be achieved or hindered. In summary, natural capital approaches use data and statistics to count the relationships between natural assets, the services they support and their benefits to humans.

An understanding and illustration of the benefits gained from natural capital and how natural capital assets support them is crucial to be able to effectively manage or improve the state of nature as outlined in the UK Government’s 25 Year Environment Plan. The relationships between natural capital assets and the benefits that flow from them are multiple and complex (NCC, 2016: 4). They are affected by how people manage the assets, and by the effects of the history of their

Figure 2
Ecosystem Services and Benefits from Soil



3. WHY SHOULD GOVERNMENTS DEVELOP NATURAL CAPITAL ACCOUNTS?

Numerous factors are leading to the depletion of natural capital assets, such as the unsustainable use of resources by humans, pollution, land use changes, and habitat fragmentation (WAVES, 2015). If these assets continue to decline below a certain threshold, the natural function of ecological systems and ecosystem service flows will be altered (Mace et al., 2015). Such changes may be severe, unpredictable or irreversible for some assets, and may lead to risk exposure for businesses and the broader economy. The Millennium Ecosystem Assessment (MA), a global assessment of the consequences of ecosystem change published in 2005, found that 60% of a group of 24 ecosystem services were being degraded, and that the overall 'state' of natural capital was in decline globally (Shepherd et al., 2016).

Currently the role of natural capital assets in supporting ecosystem service benefits is invisible to many key decision makers in business and government. At the national level, gross domestic product (GDP) looks at only one part of the economic performance of finished goods and services – usually calculated using income and expenditure. The economic activity and value of forests, oceans and other ecosystems are not recognised in the financial reporting of GDP. When a country exploits its minerals, it is depleting wealth. The same holds true for over-exploiting fisheries or degrading water resources.

These costs also have largely gone unnoticed as the services provided are typically excluded from other conventional measures of economic growth, such as within government budgets and industry input-output tables (NCC, 2015). When we use too much financial capital (loans, credit, mortgage, etc), this can result in debt and potentially bankruptcy. Similar to natural capital, when we draw down too much stock from our natural environment, we also run up a debt which needs to be "paid back." For example, by replanting clear-cut forests, or allowing aquifers to replenish themselves after we have abstracted water. If we keep drawing down stocks of natural capital without allowing or encouraging nature to recover, we run the risk of local, regional or even global ecosystem collapse. Therefore, it is crucial for governments to use natural capital assessments in their development plans to enable ongoing monitoring and assessment of natural capital stocks to maintain and restore them. Managing the stock of natural capital is key to sustaining ecosystem services flows. For example, by managing stocks of wild pollinators, farmers can maintain pollination services more effectively (Garibaldi et al., 2013).

The aim of natural capital accounting is to show how natural resources contribute to the economy, and how the activities of the economy affect natural resources, in order to inform better decisions. Comprehensive statistics, regarding such items as inputs of water or energy, and outputs of pollution, are intended to contribute to the design of better economic governing strategies overall (EU, 2017). The development of natural capital accounts has been flagged by the Natural Capital Committee as a fundamental activity that is necessary if natural capital is to be mainstreamed in decision-making. It sends a strong signal to businesses and local decision-makers of the importance of monitoring and valuing natural assets. More specifically, a well-developed national set of natural capital accounts can:

- monitor losses and gains in our natural capital over time;
- identify priority areas for investment and inform resourcing and management decisions;
- highlight links with economic and targeted industry-wide activity and pressures placed on natural capital.

Poorly managed natural capital therefore becomes not only an ecological liability, but a social and economic liability too. Overexploiting natural capital can be catastrophic not just in terms of biodiversity loss, but also catastrophic for humans as ecosystem productivity and resilience decline over time and some regions become more prone to extreme events such as floods and droughts. Ultimately, this makes it more difficult for societies to sustain themselves, particularly in already stressed ecosystems, potentially leading to starvation, conflict over resource scarcity and displacement of populations (from Natural Capital Forum, 2021).

In interviews with experts producing natural capital assessments, many noted that we still have this notion that the environment takes care of itself and that nature has the potential to restore itself, meaning we continue to keep using it as a free commodity to support economic growth. As many governments do not possess natural capital accounts or any sort of asset registry of the amount of natural capital stocks they possess, we do not have an idea of our interdependence on nature. Natural capital accounting is the best method we have got for bringing those ideas and concepts into political awareness and our policy decision making.

Recognising the value of natural capital in policy decision-making has the potential to change the way in which it is managed and used. It could contribute to a better understanding of the potential impacts of natural capital depletion, and the potential benefits of efforts to protect and enhance natural capital. In this way, valuing natural capital could help to facilitate prioritisation of issues to address, and comparison of the costs and benefits of different policy options. Moreover, placing a value on natural capital through measuring reveals that nature should not be understood by governments as a 'nice to have' that is unconnected to the economy or wellbeing, but should instead be recognised as a foundation underpinning the UK economy and society. More importantly, natural capital can help protect us from climate change. Nature-based solutions are proven ways of storing and reducing carbon emissions in the world's forests, grasslands and wetlands. At the same time, climate change accelerates the depletion of natural capital and ecosystem services as it alters major geophysical conditions – average surface temperatures, ocean temperatures, precipitation patterns, the oxygen content and acidity of seawater – far too rapidly for natural systems to adapt. Restoration is thus integral to replenishing natural capital accounts and effectively combatting climate change (Agarwala, 2014).

Through the work of the NCC, TEEB (The Economics of Ecosystems and Biodiversity), the Natural Capital Coalition, and others, the level of understanding of natural capital has grown considerably over recent years. This understanding has also come to include the potential economic and social impacts of natural capital depletion, and the potential benefits of protecting/improving specific assets. For example, highlighting the dependency many communities have on natural capital through the water people drink or on fishing and tourism industries to provide livelihoods, to identify the cause of natural capital destructions in particular places. The NCC have, however, identified a gap in the understanding of the impact of changes in natural capital on UK macroeconomic performance. More specifically, the UKNEA identified a need to improve the Government's "analytical capability around macroeconomy–environment interactions", while the NCC, in its advice to Government on priorities for research, recommended further work to promote a better understanding of "the impact of changes in natural capital upon the economy, jobs and growth" and this includes more directed research towards understanding the impact of natural capital across UK cities.

4. NATURAL CAPITAL ACCOUNTING

Across governments, natural capital accounting is being adopted as a way of making the environment more visible in economic decision making. The UK Government describes natural capital accounting as the process of recognising and valuing benefits generated by a natural capital stock (ONS, 2015). Natural capital accounts apply the key features of the natural capital approach, namely: to consider stocks of assets and flows of benefits, to use both physical measurement and economic valuation, to consider dependencies on the environment as well as impacts, and to be forward looking (Dickie and Neupauer, 2019). Natural capital accounts provide a structure that links together physical and economic data and enables more consistent analysis over time. Overall, this linkage aims to provide a more integrated approach to environmental management.

In the United Kingdom (UK), the Department for Environment, Food and Rural Affairs (DEFRA) and the Office of National Statistics (ONS) have coordinated efforts to formalise natural capital accounts into the UK Environmental Accounts by the year 2020 including the development of natural capital accounting principles and a natural capital accounting framework schedule (ONS, 2015). Tracking the proposed accounts over time allows for the assessments of changes in the extent and condition of natural assets, in addition to changes in the provision of ecosystem services. An account would report the opening and closing value of a stock of natural capital assets as well as the reconciliation of these stocks by recording net changes to assets over a particular accounting period (ONS, 2015).

As these descriptions imply, natural capital accounts require physical data that measure the extent and condition of the stocks of assets and flows of benefits they provide. Firstly, natural capital accounts consider all natural resources – both biotic (living) and abiotic (non-living) – while ecosystem accounts consider ecosystems or ecosystem services alone (Dickie, Cryle, and Maskell 2014). Secondly, natural capital accounts explicitly look at the value of the stock of natural capital assets based on the present value of the expected future flows of benefits they provide. In government planning and development, natural capital accounting can consist of identifying and assessing the natural capital assets (asset register) with and without a particular development project, calculating the flow of services from them (physical flow account), and then the monetary value of the resultant benefits (monetary flow account). Importantly it balances these benefits with the costs of creating and maintaining the natural capital assets and provides a net natural capital value for the development (natural capital balance sheet). The baseline and

post-development accounts for a site can then be compared in assessing whether the development is feasible, both environmentally and economically (Natural Capital Solutions, 2019).

Natural capital accounting demonstrates the monetary value of investing in natural assets and the financial losses that can result from lack of conservation. An assessment of the United Kingdom, for example, found that between 2003 and 2013, all forms of natural capital declined in value by more than £700 per capita (Martinez-Oviedo and Medda, 2018). A significant amount of global work has been done to mainstream natural capital accounting methodologies into macro-indicators, such as employment estimates and foreign trade. For instance, international frameworks for developing national natural capital accounts include the System of Environmental-Economic Accounting (SEEA) and Wealth Accounting and the Valuation of Ecosystem Services (WAVES). These frameworks have developed standardised processes for natural capital accounting that incorporate natural assets, such as forests and water, alongside traditionally measured assets in the national economy.

These frameworks however are country specific, and work is not fully developed yet on how to monitor and assess natural capital in particular local ecosystems, such as a park or a city region. Natural capital accounting can help subnational governments, such as municipal governments, to make better informed investments by providing a consistent and widely used framework for including natural assets in decision making. In 2017, Eftec (Economics for the Environment Consultancy) conducted a study using natural capital accounting frameworks in UK cities. This included both physical and monetary accounts of the natural assets located in 'urban environments' and estimates for the following ecosystem services: physical health, local climate regulation, noise regulation, air quality regulation, food provision, and global climate regulation. Using a range of different evidence, Table 1 below shows the annual value of ecosystem flows from UK urban natural capital (Eftec, 2017: 21). The account below developed for urban areas shows the significant value provided by natural capital. Amongst those benefits captured, the most significant are physical health and air quality regulating impacts.

Table 1

Monetary Accounts: Ecosystem Service Flows from UK Urban Natural Capital

Benefit	Coverage	Amount	Unit	Type of value	Source(s)
Food	UK	£114m	£m/yr	Market value	Cook (2006); Pretty (2001)
Climate regulation – global (carbon)	UK	£31m	£m/yr	Cost of carbon mitigation	DECC (2014)
Air quality regulation	PM _{2.5}	£195m	£m/yr	Welfare value and avoided market costs	Defra (2014)
	SO ₂	£0.3m	£m/yr		
	NO ₂	£13m	£m/yr		
	O ₃	£3m	£m/yr		
Noise regulation	Manchester	£59m	£m/yr	Welfare value of dBA reduction	Defra (2014)
Climate regulation – local	GB	£70m	£m/yr	Market values – avoided loss in GVA and avoided air-conditioning cost	Costa et al. (2016); ONS (2016)
Physical health from outdoor recreation	UK	£1,482m	£m/yr	Welfare value (QALY)	Beale et al. (2007); White et al. (2016)
	UK	£900m	£m/yr	Avoided total cost	Public Health England (2015); Bird (2004); DoH (2004)

Source, Eftec, 2017

5. NATURAL CAPITAL AND CITIES

The continued growth of cities is a major driver of environmental change and shifting patterns of natural capital and the services provided to society (Gómez-Baggethun et al., 2013). A large body of research has emerged to address urban changes to natural capital assets (Hubacek and Kronenberg, 2013). This has included analyses of the generation of stormwater, health, noise, and other “green infrastructure” benefits of vegetation and urban green spaces (Jansson, 2013). Studies have also identified land conversion (i.e. the development of land) as a major cause of ecosystem service changes in cities over the last several decades, and speculate

it to be a major cause of future natural capital loss (Eigenbrod et al., 2011; Kreuter, Harris, Matlock, & Lacey, 2001; Su, Xiao, Jiang, & Zhang, 2012).

Cities have a significant number of options for investing in green development by planning, creating, and maintaining urban natural assets in and around the city. Urban natural assets consist of networks of natural and semi-natural features in cities, including both green infrastructure and natural habitats.

Case Study A

London and Accounting for Greenspace

London is considered one of the greenest cities in the world for its size. It comprises more than 47% greenspace (parks, garden, and woodlands) and 2.5% bluespace (ponds, canals, rivers and lakes) (London Councils, 2018). Most of London’s parks and other areas of biodiversity are owned or managed by the London boroughs, other public agencies (such as The Royal Parks and Lea Valley Regional Park Authority) or environmental organisations. Many of these governance and management arrangements are supported by grants or contracts from local authorities. However, with constraints on public funding, many are struggling to invest in, and maintain, public green spaces. Thus, it has become a priority to use natural capital accounting to value London’s green spaces.

In 2014 the Green Infrastructure Task Force assessed the economic benefits of green spaces and explored possible ways to improve the delivery of the parks service, as well as funding options. The production of natural capital accounts was a Green Infrastructure Task Force recommendation (World Bank Cities, 2018).

Around a fifth of London is designated as publicly accessible parks comprising 32,000 acres (GLA, 2017). London’s public parks have a gross asset value of more than £91 billion (GLA, 2017). The value of parks reflects their general amenity, benefit to health and opportunity for exercise, and the value of recreation. Individuals, public services and businesses all benefit from public parks across the city. Londoners avoid £950 million per year in health costs due to public parks. Public parks create opportunities for people to exercise,

socialise, relax and enjoy being part of their community. In doing so, people improve their physical and mental health. This total avoided cost is made up of £580 million per year by being in better physical health and £370 million per year by being in better mental health. The health benefits of London’s public parks amount to 20% of their total economic value. For every £1 invested by boroughs on public green spaces, £27 of net value is delivered to Londoners. The accounts have identified however that while the borough incurs the costs, it is residents that see 90% of the benefits. Recreational activities, such as football or personal training, taking place on London public green spaces are valued at approximately £926 million per year.

Other benefits from green spaces are environmental. The urban heat island effect means cities and urban areas are significantly warmer than surrounding rural areas. Green areas within cities can help reduce this effect, countering high summer temperatures, which helps combat associated ill health. There are also benefits from carbon storage, with 3.1 million tonnes of carbon held in London’s trees, giving an estimated benefit of £8 million per year.

The challenges of borough funding for parks and green spaces, a non-statutory service, are acknowledged in the accounts. The Heritage Lottery Fund considered the state of the UK’s public parks in 2016, and it outlined an expectation that future green space funding would decrease by up to 20% by 2020 (London Councils, 2018). Therefore, the natural capital accounting work reframes London’s public parks as value-creating natural assets. This analysis has helped managers of these assets make the case for sustained or greater spending on parks rather than costly liabilities.

According to the World Bank (2020), specific types of natural assets in urban areas often include:

- Small built features: Green roofs/walls, green corridors, street trees, small green spaces, water;
- Medium spaces: City farms, public squares and commons, sport pitches, public/domestic gardens;
- Urban parks: Local parks, regional or national parks;
- Natural areas: Wetlands, rivers, and woodlands.

Urban natural assets comprise elements that provide multiple ecosystem services unique to cities. Many natural capital assets are fundamental to regulating services that maintain the quality of the environment within cities, while other features such as green rooftops can improve the overall aesthetic of a neighbourhood, increasing property values. Large green spaces often provide opportunities for physical activities and recreation, and thus support the livelihoods of residents (See Case Study A on green spaces in London). Parks and waterfronts also have an intrinsic value to urban residents that may be associated with ethical and cultural reasons.

Work on quantifying the role that urban natural capital assets play for city residents has been increasing in recent years. Landmark studies have been conducted at scales relevant to cities. For example, urban natural capital accounts have been undertaken in global cities like London, and smaller urban areas in the UK, such as Belfast, Birmingham and Greater Manchester (Vivid Economics, 2017; Urban Pioneer, 2019; Coldwell, Rouquette, and Holt, 2018), as well as in various North American cities, including Toronto, Vancouver, Philadelphia and New York. These accounts have successfully demonstrated the value of urban natural assets and are reframing the way cities think about investing in the environment. Cities are also working to integrate biodiversity considerations into the management of their natural assets by quantifying and monitoring the role that diversity of habitats and species plays both in and around cities.

Case Study B

City of Toronto and Ravines



Source: City of Toronto, 2018

Toronto's ravine system provides many benefits to the people of Canada's most populated city, including improved air quality from the filtering effects of trees, recreation and active transportation opportunities, aesthetic benefits from natural landscapes, and cultural and spiritual benefits. These ecosystem services provided by the natural capital of the ravines are significant contributors to the health and wellbeing of the residents of Toronto and its surrounding regions. In 2018, Green Analytics was commissioned by the City of Toronto and Toronto and Region Conservation Authority (TRCA) to provide an assessment of ecosystem service values provided by the natural capital within the ravine system. Thirteen ecosystem services provided by

natural capital in the ravine system were considered, and monetised benefit estimates were derived for eight of the thirteen services (City of Toronto, 2018). Ecosystem services for which monetised estimates were derived include:

- Recreation;
- Physical health;
- Mental health;
- Gas regulation (e.g. air quality);
- Carbon sequestration;
- Food provision;
- Aesthetic appreciation;
- Habitat and refugia.

Based on the monetised benefits, the total annual value of the ravine system's ecosystem services is estimated to be \$822 million. The largest benefit derived from ravines in Toronto is by far recreational activity which is valued at \$584 million. Recreation activities that take place within the ravine system include walking/hiking, biking, picnicking and birding (City of Toronto, 2018). The second largest benefit is physical health where access to greenspace is associated with increased levels of physical activity resulting in avoided costs of ill health due to inactivity. The annual value of physical activity occurring in the ravines ranges from \$140 million to \$217 million (City of Toronto, 2018). These values can inform the potential implications of land use and resource management policy decisions in the region. More importantly, these results are now being used to incorporate in the City of Toronto's municipal asset management process where they are working to build an asset inventory of the ravine system and measure its condition, along with applying the same natural capital accounting framework to urban forestry assets throughout the city.

Through linking management and investment in natural assets to physical and economic metrics, natural capital accounting techniques are being used by cities to prioritise and mainstream green urban development. Urban natural assets provide a range of benefits to urban residents, the environment, and the city economy. These include improved health and well-being for residents, support to wildlife and habitats, and regulation of temperature, air, and water quality (Vivid Economics, 2017). Improvements in a city's quality of life generally explain a substantial part of its employment growth due to increases in human capital (Shapiro, 2006). Thus, attractive and healthy cities are also often the most productive and globally competitive (Economist Intelligence Unit, 2018).

When natural capital is destroyed, or its ability to provide an ecosystem service is impaired or lost, the service must be replaced for people to continue to derive the benefits that were provided by the natural system. Engineering the replacement of a service nature provides often requires expensive new infrastructure with significant operational and maintenance costs. In the long run, the protection of natural capital and the services it provides is often the most cost-effective option. This realisation is now being incorporated into many municipal initiatives that consider natural capital assets as "green infrastructure". For instance, the Green Infrastructure Ontario Coalition defines green infrastructure as the natural vegetative systems and green technologies that collectively provide society with a range of economic, environmental and social benefits. While the emphasis has been on preserving existing natural capital assets, increasingly municipalities and agencies are looking to restore and enhance natural capital assets as well. Case Study B describes how the City of Toronto has used natural capital accounting to realise the significant economic value from services and benefits that flow from its ravine system, particularly regarding savings when it comes to health services.

Natural capital accounting methodologies are evolving to account for the role natural assets play in cities and assessing the value of public parks and urban waterbodies (Vivid Economics, 2017). These accounts are also evolving to assess the value of localised green infrastructure investments, such as street trees, and to quantify the ecosystem services that support liveable cities. This has been done through assessing the value of recreation (Iamtrakul, Teknomo, and Hokao 2005), impacts on human health (White et al., 2013), and flood risk reduction (Kim, Lee, and Sung, 2016). For instance, natural capital accounting in London has helped transform the perception of green space – from something costly to provide and manage to a value creating asset (Vivid Economics, 2017).

6. BARRIERS IN PURSUING NATURAL CAPITAL ASSESSMENTS IN CITY GOVERNMENTS

Natural capital assets are either undervalued or not valued and therefore not included in urban development evaluation methods and on balance sheets of city budgets. Despite its importance, the value of natural capital is taken for granted. According to the Natural Capital Committee (2019), the benefits that come from nature are not taken into account in decision-making and there is growing evidence that not monitoring natural capital leads to uninformed decisions, damages the environment and has significant consequences for the economy.

For example, Birmingham City Council's conventional balance sheets show its parks as a liability. Traditional accounting methods focus on a park's operational costs associated with maintenance (see Table 2). Therefore, these parks are considered as financial liabilities rather than the 'external' benefits provided to our wellbeing. They also deliver a range of ecosystem services such as improved air and water quality, flood risk mitigation by absorbing water run-off, and cooling the urban environment as well as providing much-needed habitat for wildlife (Capitals Coalition, 2017). By using a "natural capital" accounting approach that puts a value on all these social, environmental and economic contributions, Birmingham discovered that for every £1 spent on its parks, they generate £25 of benefits annually (Public Health England, 2020). The assessment shows that Council-managed parks and greenspaces represent a net natural capital asset with an indicative value of £11 billion over a 25-year period and net annual benefit of £600 million (Holzinger and Grayson, 2019: 4-10). Therefore, to take seriously the full value of natural capital and its benefits, local governments need to rethink how they use finance to monitor progress. Purely relying on conventional accounting when informing budget decisions affecting parks and greenspaces could easily result in unintended outcomes such as a net-decline in Council finance.

In addition, the systematic assessment of ecosystem services and natural capital within the scope of a development project can be very challenging and faces a range of barriers. It is arguable that one main reason for this lack of implementation is that relevant evidence, e.g. from national assessments of ecosystem services, is hard to assimilate and to take up at the local and site scale where most planning decisions take place. Such planning decisions have a considerable impact on land. Also, developers and their agents do not always have the technical expertise available in-house. The same applies for many planning authorities. In 2019 only about 25 per cent of English local authorities had an in-house ecologist and in 2007

planning officers only received ecological advice for just over 50 per cent of their planning cases (Parsons, 2019). It should also be mentioned that such ecologists are often specialised in biodiversity issues rather than the wider range of ecosystem services. This limits their ability to assess and judge the impact of proposed development projects on ecosystem services and to compare related values and their inherent impacts on human wellbeing with other benefits such as new households or jobs created.

Relatedly, through interviews with natural capital experts, some emphasized how city government and local policy-makers need more training in the use of natural capital and why using a natural capital assessment or accounting is useful to them. The obstacle to green cities is authorities' and urban residents' limited understanding of the benefits of green infrastructure and development. One reason for this is that ecosystem services thinking and its dedicated terminology can be extraordinarily complex, and developers and planning authorities are often not familiar with the concept and related methodical approaches. This has led to some city authorities being focused on achieving short-term urbanisation goals, often at the expense of long-term sustainable planning and outcomes.

Case Study C describes the City of Birmingham working with stakeholders to develop an accessible and easy to use natural capital assessment tool to monitor and increase green space as part of their Green Living Spaces Plan.

However, such detailed assessments are resource intensive and therefore difficult to fund for local governments. Many cities lack the financial capacity to undertake natural capital assessments. It can be a costly and complicated project to sit down and think about interactions with the environment. Local budgets for green infrastructure are already constrained because their benefits are not well understood; and as demand for land for housing increases, budgets come under further pressure. Investments in green infrastructure could be subject to cities' capacity to leverage finance and their ability to raise up-front investment capital. According to one environmental economist interviewed, capacity to engage with local governments across the UK to develop natural capital accounting is very limited in comparison to work being carried out with national or regional level government agencies. This is attributed to limited resources and the lack of in-house ecologists and environmental economists.

The application of such tools is also very demanding in terms of the expertise required and the time commitment. For instance, at the moment, the local planning system in England and most of the world is not systematically accounting for the impact of development and inherent land-use changes on natural capital and ecosystem services. Investment and continuous effort will be required to for local governments so that NCA becomes fully effective, efficient and embedded in a city government's decision-making.

Case Study C

Nature Tool Developed by Birmingham Council

The screenshot displays the 'Nature Tool' interface, which is an Excel-based assessment tool. It features a 'Habitat Areas' tab and a 'PLEASE SELECT SHEET STATUS' dropdown menu. The main table is organized into columns for 'Category', 'Sub-category', 'Habitat Area', 'Duration', '0 Years', '25 Years', and '100 Years'. The table lists various habitat types such as 'Woodland & scrub', 'Parkland & screened areas', and 'Moorland'. Each habitat type is further broken down into specific sub-categories, and each sub-category is associated with a list of ecosystem services. The table uses a color-coded system to indicate the status of each service, with green representing positive impacts and red representing negative impacts. The bottom of the interface shows navigation tabs for 'Assessment Status', 'Project Info & Outputs', 'Habitat Areas', and 'Partnered Habitats'.

Source: Nature Tool Template, 2021

The City of Birmingham estimated the stock of natural capital assets and flow of ecosystem services at a city-wide level as a basis to establish targets for increasing greenspace as part of the City's Green Living Spaces Plan and to inform a 25-year Natural Capital Plan. The Green Living Spaces Plan assessment includes indicative monetary values in annual terms and asset values (over 100 years) based on value transfer. The city adopted the Natural Capital Planning Tool (NCPT) to inform planning and policy for sustainable land use. This tool was developed in tandem

with the City Council, CEEP (Consultancy for Environmental Economics and Policy) and the UK Business Council for Sustainable Development, to create an NCA assessment of ecosystem services that used a scoring system to rate ecosystem services performances of different land-use options (Hölzinger, and Grayson, 2015). Altogether the project team was able to recruit 45 task group members for this project.

The Natural Planning Tool (NCPT) enables the indicative but systematic assessment of the impact of proposed developments and plans on natural capital and ecosystem services. Ten different ecosystem services can be assessed by the tool with an assessment timescale of 25 years. The development of an Excel-based Natural Capital Planning Tool (NCPT) allowed non-specialists to assess the impact of proposed developments and inherent land-use changes on ecosystem services (Hölzinger, and Grayson, 2015). Ecosystem services measured by the City's Green Living Spaces Plan include harvested products, biodiversity, aesthetic values, recreation, water quality regulation, flood risk regulation, air quality regulation, local and global climate regulation and soil contamination (Efttec, 2017). Because the potential tool users are not always ecosystem services specialists and frequently have to make decisions under high time pressure the outcomes of the tool should be simple and easy to interpret; but still meaningful.

The NCPT has been successfully used in three different case studies. These were: an urban housing development for Birmingham City council; a flood alleviation scheme by the UK Environment Agency in Rugeley, Staffordshire; and construction company Skanska's re-development of its manufacturing facilities in Doncaster. The City of Birmingham is at the forefront of natural capital accounting and exploring opportunities to ensure natural capital is integrated into land use and planning decisions.

Table 2

Birmingham Parks and Greenspaces: Total Asset Value Over a 25 Year Assessment Period

<i>Capitalised/stock values stated in £billions; 2018 prices; central estimates</i>	Adjusted values for aggregation (to avoid double-counting)			
	Total natural capital value	Health benefits	Direct and indirect Council income	Conventional accounts
Assets				
Property value uplift	£4.75			
Council Tax uplift	£0.48		£0.48	
Physical health benefits	£4.06	£4.06		
Mental health benefits	£0.20	£0.20		
Air quality regulation	£0.30	£0.30		
Recreation	£1.03			
Global climate regulation	£0.22			
Food production from allotments	£0.07			
Biodiversity (non-use benefits only)	£0.04			
Flood risk regulation	£0.03			
Direct parks income	£0.23		£0.23	£0.23
Adjustments	-£0.01		-£0.01	-£0.01
Gross asset value	£11.41	£4.56	£0.70	£0.22
Liabilities				
Parks services expenditure	£0.44	£0.44	£0.44	£0.44
Net value	£10.97	£4.13	£0.27	-£0.22
	to society	in health benefits	to the Council	as per books
Benefits-cost ratio	26.2 : 1	10.5 : 1	1.6 : 1	0.5 : 1

Source: Holzinger and Grayson, 2019

7. IMPROVING NATURAL CAPITAL ASSESSMENTS FOR CITY GOVERNMENTS

“How are we going to meet a climate challenge or an ecological change, if our only measure of success is we’ve balanced the budget?” (UK Local Government Official)

- 1. More Funding:** Public money needs to be invested in the design and development of publicly available tools, tailored for non-specialists, to support the development of natural capital accounts where interdisciplinary knowledge, technical and analytical skills are not available in-house. This would help promote and support standardisation of tools and methods to incorporate natural capital considerations into socio-economic decisions. To facilitate large-scale investment into natural capital, there can be a range of financing models development that are targeted for local governments. This can range from traditional debt and equity structures to more innovative finance approaches designed to support investment into a range of natural capital projects (such as impact investment funds, green bonds, and/or environmental impact bonds). For example, the Greater Manchester Combined Authority is currently in the process of creating a “Greater Manchester Environment Fund” as a vehicle to raise a blend of public, philanthropic and private capital for natural capital projects across Greater Manchester. This type of coordinated investment fund can leverage additional private finance by providing the initial source funding into projects before they are revenue-generating (Eftec, 2019).
- 2. Better Data:** More routine collection of locally specific, easily accessible, data to ensure greater consistency and reliability in the quantification of changes in natural capital asset extent and condition, ecosystem services’ flows, and their changing value over time. Currently, data needed to conduct NCA effectively is managed by various government agencies. As one ONS government official interviewed mentioned, “you have to know a whole lot about how the government works to be able to find the data you need.” For example, Natural England holds some data on habitat conditions, whereas FERA Science has data on plant production, pollination, agriculture and pesticides (FERA, 2021). It is time consuming and resource inefficient to be able to navigate how and where to find the data. In many ways, it would be crucial to create institutional links to mainstream natural capital in other policies (e.g. breaking down the silos between ministries by providing means for data sharing, creating channels for integrating different policy areas and establishing interdepartmental steering committees).
- 3. Embedding Natural Capital into Policy:** Currently, planning and practice take a project-by-project approach to considering environmental impacts – meaning the interactions and interdependencies of natural capital are often not considered and cumulative impacts of development may not be fully understood. Therefore, it is important to develop an integrated approach of natural capital assessments and policymaking. This means we must transform how we use evaluation methods at the government level, such as the use of cost-benefit analysis. This means improving the models we use to evaluate a policy or program that is sensitive to the interconnectedness of nature and local services. This means institutionalising NCA across local government systems and integrating natural capital in decision-making and public sector management. Natural capital needs to be embedded within the appraisal of projects and development. This can be done through further research and development in the field of natural sciences and economic valuation methods, to ensure that public goods, such as biodiversity, flood protection, cultural heritage and landscape values, can be suitably represented in Natural Capital Accounts. Despite tools such as the Natural Environment Valuation Tool (NEVO), a tool that helps policymakers make predictions about land changes, very little such information is publicly available through datasets, which represents a major data gap.
- 4. Improving Communications Between NCA Producers (Economists and Finance Experts) and Local Policy-Makers:** It is imperative that changes to governance structures be made to create an integrated and streamlined approach to natural capital accounting in policymaking. This means finding ways to enhance coherence between different government departments, agencies and actors that had been working on separate areas previously. For some national governments, this has had the effect of breaking down silos between government departments. For example, many countries have already had notable achievements, leading to the institutionalisation of natural capital accounting within the statistical offices (e.g. in Colombia), ministries (e.g. in Rwanda) or central banks (e.g. in Costa Rica) (Ruijs, 2019). Natural capital accounting should be designed specifically with cross-sectoral, institution-linking and long-term sustainable planning in mind. Adopting such a collaborative approach helps link the producers of NCAs, the users of NCAs for policy analysis and the policymakers using the NCA results together.

5. Education and Building Awareness: Ecosystem service valuation has the potential to be used to increase citizen awareness and corporate understanding of the value provided by nature. By estimating the monetary value of nature's contribution to society wellbeing, people can identify a greater trade-off in preserving nature and biodiversity and can assess that value on equal footing with other monetised goods and services.

8. CONCLUSION AND FUTURE DIRECTIONS

Effective management of natural capital in the future depends on how well the services of biodiversity and nature are understood by those who manage and fund them. Natural capital accounting is an emerging way of presenting information about the value of the environment. The goal is incorporation of this information in formal accounts, which would be recognised by those involved in financial and management decisions.

Earlier sections of this paper have discussed the progress made towards measuring natural capital in the UK and elsewhere, as well as the constraints local governments face in incorporating natural capital accounting into policy-making decisions. Since natural capital is a fundamental component of wealth, the evidence base must include the most complete data available on natural capital, their changes over time, and the exchange of goods and services between the environment and the economy,

Natural capital accounting presents opportunities for collaboration between government policy-makers, social scientists, economists and accountants to demonstrate the value of enhancing green spaces and biodiversity throughout our communities. The formation of these accounts could provide a way of prioritising the potential beneficiaries of changes to the environment. In the context of local austerity and cuts to public parks, the practice of showing nominal (e.g. £1) rather than real asset values for such spaces in local authority accounting is a challenge. Natural capital accounting can help local authorities show estimates closer to the real asset value (even if the accounts are incomplete) and thereby prove the economic value of public parks for continued or new funding for urban greenspace.

We see natural capital accounting as a valuable tool in helping inform local governments' strategic decision-making and long-term planning in sustainability, enabling the monitoring and the effects of climate change on natural capital, and in some cases informing investment and local development decisions.

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