Environmental policy narratives and urban green infrastructure: reflections from five major cities in South Africa and the UK

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Abstract

In the context of large and growing urban populations, there is a pressing need to understand how the urban environment can be sustainably planned, developed and maintained for greatest benefit to people and nature. The use of 'green infrastructure', as a framing approach for integrating urban green space into urban decision-making claims significant international impact. This paper describes key urban environmental policy narratives of five different urban areas (Cape Town, Durban and Johannesburg in South Africa and Birmingham and London in the UK) reflecting on the way that they have brought green infrastructure concepts into their decision-making.

This multi-method study includes analysis of academic papers, technical reports and policy documents and semi-structured interviews with academics, practitioners (planners, engineers, environmental consultants), policy-makers and local community actors. This work has highlighted significant differences in the explicit use of urban green infrastructure as a framing within environmental policy, shaped by the mix of biophysical, social and economic factors that dominate the policy priorities of each city. It adds to a growing evidence base from research and practice aimed at supporting effective urban environmental policymaking.

Keywords: Sustainable urbanization, Urban ecosystem services, Green infrastructure, Knowledge systems, Decision-making

1. Introduction

The global urban footprint continues to grow, with more than 55% of people now living in cities, the highest rates of urbanization shifting from the global north to the global south and significant new construction taking place on previously undeveloped land (United Nations, 2018). Understanding the role and significance of green space as part of the broader urban environment is, therefore, of critical importance. With the increasing global urban dominance comes a growing commitment to ensure that cities are safe, healthy and equitable places to live and thrive; encapsulated in many global development agendas. 'Safe, inclusive, accessible, green, and quality public spaces' is an explicit aim of UN-Habitat's New Urban Agenda (UN Habitat, 2016). In Agenda 2030 target 11.7 of SDG 11 reads: 'by 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities' (United Nations, 2015). These agendas recognise both the importance of green spaces in urban areas and the need for a robust understanding of how these spaces might be planned, developed and managed to greatest benefit of all.

The benefits of urban green and blue space have long been recognised in academia, decision-making, urban planning and wider society. Victorian parks, US greenways, Garden Cities and New Towns (Batchelor, 1969; Benedict and McMahon 2002, 2006, Fabos 1995, Hebbert 2008, Mell 2008; Richert and Lapping, 1998) are all results of this, and more recently the ecological city and sustainable urbanism (Ahern 2007, Wright, 2011). Over the last two decades, empirical understanding has grown around the range of specific and general benefits that green spaces provide to urban inhabitants and to the wider environment (Kabisch et al., 2015; Lee & Maheswaran, 2011). Green spaces, planned or unplanned, can deliver a large range of biophysical and social benefits critical to the sustainability of dense and growing populations, including: mitigating flooding, improving air and water quality, cooling the urban environment, enhancing biodiversity and ecological resilience and promoting healthy living by encouraging healthy eating and active transport and improving mental health and wellbeing (Gómez-Baggethun et al., 2013; Kabisch et al., 2015; Lee & Maheswaran, 2011). They can also play a direct role in providing resources, services and

economic opportunity which are particularly critical in developing urban contexts (Lindley et al., 2018; O'Farrell et al., 2019).

In response to this, a range of new terms and approaches have been progressively adopted for integrating urban green space concerns into environmental policy. Among these, 'green infrastructure' (GI): "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict & McMahon, 2002) has become widely used in planning and decision-making (Amati and Taylor, 2010; Hansen & Pauleit, 2014; Mell, 2008). Green infrastructure as a term and approach has largely evolved in Europe, North America and Australia, however, it is being increasingly adopted in a range of other global contexts (Lindley et al., 2018; Matsler et al, 2021; Matsler, Miller & Groffman, 2021). What is included within the definition can demonstrate marked "temporal, geographic, scalar and disciplinary variation" (Mell and Clement, 2020). It appears "both as a broad planning/ecological network approach and as a narrow engineering technique" (Matsler et al. 2021) and often encompasses ideas of: "connectivity, multi-functionality, access to nature, integrated policy/practice, and an understanding of the socio-economic and ecological benefits of effective landscape management" (Mell and Clement, 2020). Matsler et al's (2021) review paper outlines three conmon categories for green infrastructure, globally, as "1) a greenspace planning concept, 2) an urban ecology concept, and 3) a water/stormwater management concept".

Green infrastructure is one of a number of terms increasingly used to formally and informally describe the aforementioned benefits that humans derive from the natural environment, in an economic and non-economic sense, in order to support environmental decision-making. It frames values and functions in a way that is intended to be familiar and recognisable in terminology (i.e. 'infrastructure') to those practically involved in the design, creation and maintenance of urban green spaces including planners and engineers (Mell, 2009; Roe and Mell, 2012). The extent to which it has been a useful tool in discussion and action around urban green space has been a topic of extensive debate (Mell 2009; Lennon 2015; Wright, 2011), and a number of city-level case studies already exist (Cortinovis and Genelettil, 2018; Frantzeskaki, 2019; Di Marino et al., 2019; O'Donnell et al., 2017;

(Reimer & Rusche, 2019; Sanesi et al., 2017; Shackleton et al., 2017). However, little work has sought to understand the interplay between the broader environmental policy approach of the cities and green infrastructure and few studies have focussed on cities of the global south (Burton and Rogerson, 2017) where green infrastructure could be an enabler 'for cities to start rethinking sustainable development strategies in urban areas and providing more resource efficient infrastructure options' (Bobbins and Culwick, 2015).

This paper uses the term 'narratives' to describe key themes that appear in environmental policy making in different cities. Put simply, a 'narrative is a story' (Bevan et al. 2020). 'Narratives' are ways of framing language to promote or prioritise particular ideas or values, to convey meaning to those who: 'live, create or interpret them' (Fisher 1984). Narratives which are sustained over time and space can be instrumental in shaping and directing policies that are developed and adopted and actions that are taken as a result. It draws upon groundwork laid by papers using 'framing' and 'storytelling' to understand narratives around green infrastructure and urban nature (e.g. Frantzeskaki, 2019; Mell and Clement, 2020; Reimer and Rusche, 2019). Mell and Clement (2020) note that: "it is clear that certain 'storylines' about what GI is, what it can do for society and the environment, and how it should be implemented dominate a given geographic context". This paper, therefore, seeks to understand the way in which broader urban environmental policy narratives interplay with the emergence of 'green infrastructure' in the policy discussions of five cities: Cape Town, Durban (eThekwini) and Johannesburg (including the immediate Gauteng City-Region) in South Africa and Birmingham and London in the UK.

2. Methods

2.i Study locations

The study locations were chosen based on preliminary work undertaken by the author in understanding engagement of cities with urban green space decision-making (working paper, unpublished). This study sought to include cases from global north and global south contexts; there is a particular paucity of research surrounding green infrastructure in sub-Saharan Africa (Lindley et al., 2018). Both the UK and South Africa were identified as suitable candidates through this

preliminary work and the sample includes the two cities in the UK and three in South Africa where green infrastructure had the most immediately visible presence in policy discourse.

The cities are located in different ecological, social and economic contexts, with key statistics captured in Table 1. They include both capitals and secondary cities to ensure that observations do not solely relate to the 'special case' of capital cities (Turner and Turner, 2011), though it is noted that all cities studied are major centres of population and economic activity within their country context. While the city examples are intended to be descriptive and 'illustrative', producing "case-based knowledge" on the five different contexts (Remier & Rusche, 2019), some broad contrasts, similarities and patterns are drawn out across the cases using a comparative lens (Mills et al 2010). This study worked on the basis that 'synthesizing across cases holds promise for building knowledge that is more generally useful and can inform policy, programs, and practice.' (Mills et al 2010).

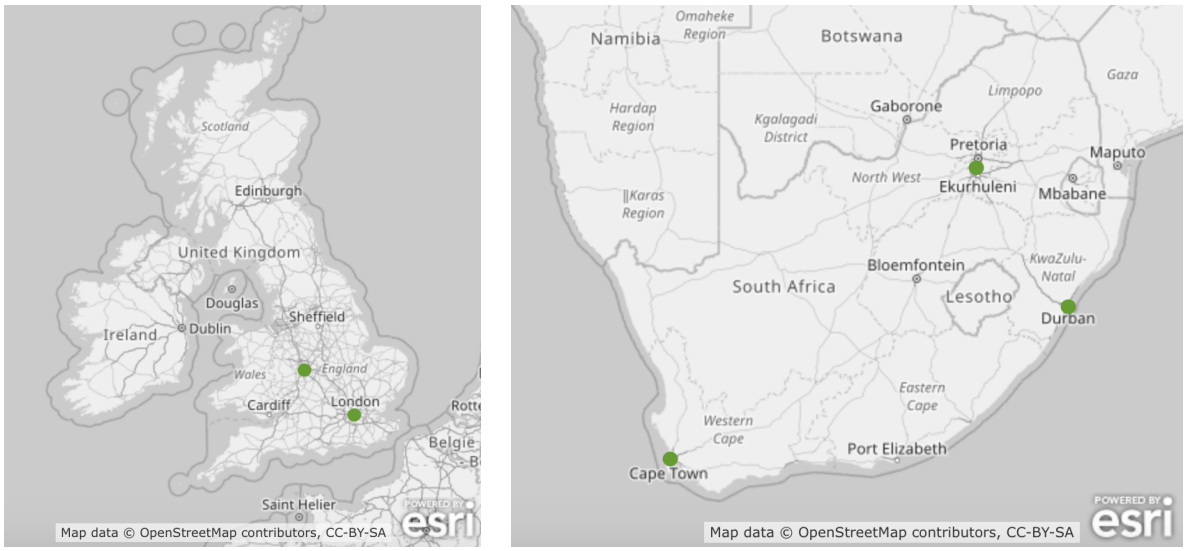

Figure 1: Location of case study cities (base map ESRI, accessed October 2018)

Table 1: Case study key statistics

City	Designation	Population	History
Cape Town, South Africa	Capital (legislative) (2nd largest urban agglomeration [a] by population) (United Nations, 2018)	4.4 million (United Nations, 2018)	Established since 1652 Current size: 2,461 km² (Statistics South Africa, 2020a)

Durban (eThekwini), South Africa	Secondary (4th largest urban agglomeration [a] by population) (United Nations, 2018)	3.1 million (United Nations, 2018)	Named in 1835 (colonial city) Current size: 2,297 km² (Statistics South Africa, 2020b)
Johannesburg, South Africa	Secondary (largest urban agglomeration [a] by population) (United Nations, 2018)	5.5 million (United Nations. 2018)	Established since 1886 Current size: 1,645 km² (Statistics South Africa, 2020c)
Birmingham, UK	Secondary (3rd largest urban agglomeration [a] by population) (United Nations, 2018)	1.14 million (Office for National Statistics, 2019a	Established since 12th Century AD Current size: 268 km² (Office for National Statistics, 2019b)
London, UK	Capital (largest urban agglomeration [a] by population) (United Nations, 2018)	8.9 million (Office for National Statistics, 2019a)	Established since 1st Century AD Current size: 1,572 km² (Greater London Authority, 2019)

[a] urban agglomeration = "extent of the contiguous urban area, or built-up area, to delineate the city's boundaries." "The 2018 revision of World Urbanization Prospects (WUP) endeavoured wherever possible, given available data, to adhere to the "urban agglomeration" concept of cities." (United Nations, 2018)

2.ii Approach

A multi-method approach was adopted, which sought to ensure that documentary evidence about and from the cities was cross-referenced with lived experience. The approach was based on development of multi-site case studies (Mills at al 2010) through initial document analysis of academic papers, technical reports and policy documents, which guided the form of semi-structured interviews with academics, practitioners (planners, engineers, environmental consultants), policy-makers and local community actors (local residents, members of interest groups relevant to urban green infrastructure e.g. 'friends of parks' groups). A breakdown of the approach can be seen in Table 2.

Table 2: Research areas, indicators and sources

Framing	*Indicators*	*Sources*
Urban environmental policy narratives	• Common phrases and framings, key environmental focus areas and justifications	• Policy documents, semi-structured interviews with key informants
Wider policy priorities	• Basic mapping of the interlinkage of environment and other policy priorities such as health and economy	• Policy documents, semi-structured interviews with key informants
Definitions and understanding of GI	• Definitions, phrases and examples used	• Policy documents, academic papers, technical reports, semi-structured interviews.

Governance, policy and decision-making using GI	• Current policies in place • Future enablers identified	• Policy documents, academic papers, technical reports, semi-structured interviews.
Opportunities and challenges around GI	• Opportunities and challenges for promoting green infrastructure approaches	• Policy documents, academic papers, technical reports, semi-structured interviews with academics, practitioners (planners, engineers, environmental consultants), policy-makers and local community actors.

a, Document analysis

Environmental policy documents for each of the cities were downloaded from the websites of relevant city governance body: Cape Town (City of Cape Town and Western Cape Government), Durban / eThekwini (eThekwini Municipality) and Johannesburg (City of Johannesburg and Gauteng Provincial Government), Birmingham (Birmingham City Council), London (Greater London Authority). As well as the current policies in place, any preceding versions (within the previous 15 years, where publicly available) were also added to the corpus. For greatest breadth of coverage, other technical reports, planning guidance and policy documents were identified through online searches using Google search and the keywords and search phrases (including city name): 'environment', 'green space', 'green infrastructure' + common policy document types: 'plan', 'policy', 'guidance', 'framework', 'toolkit'. Academic papers were identified through Mendeley and Google Scholar using the search phrase (including city name): 'green infrastructure'. These documents formed the corpus for each city. The full list of documents analysed can be seen in Supplementary Material, Table 1. 12 academic papers, 7 technical reports and 28 policy documents were analysed in detail. These documents were imported into and analysed using NVIVO. With the exception of the term 'green infrastructure', all documents were analysed inductively, using thematic analysis to record specific themes as they emerged. NVIVO's analysis capabilities were used to provide a rapid quantification of prevalence (word count) of key terms and phrases of interest ('Green Infrastructure' + abbreviation 'GI') Supplementary Material, Table 2.

b, Interviews

Interviews were carried out with academics, practitioners, policymakers and community actors across the case study cities under UCL low-risk ethical approval (references 8349/002 and 8349/003). These

168 took place in 2017 and 2018, virtually (via Skype) or in person. Interviews were semi-structured, with
169 questions guided by key themes identified in the document analysis: 'use of green infrastructure'
170 (research questions: 'green infrastructure as a concept', 'green infrastructure in practice'), 'utility of
171 green infrastructure' (research questions: 'green infrastructure in practice', 'knowledge and skills for
172 green infrastructure', 'engaging different communities') and 'integration of green infrastructure in
173 policy' (research question: 'governance, policy and decision-making'). Research questions can be
174 seen in Supplementary Material 3. 31 interviews were conducted and a summary by city and sector
175 can be seen in Table 3. Interviewees were selected from contacts working within the relevant areas
176 of environmental decision-making and planning identified through documents within the corpus.
177 Interviewees were all asked to suggest further relevant colleagues as part of a snowball sampling
178 approach. Interviews were transcribed in to NVIVO from audio recordings and written notes and
179 transcripts were thematically analysed using NVIVO. Thematic analysis aimed to derive qualitative
180 insights into the way in which green infrastructure was spoken about by different individuals, mapping
181 out the contexts in which it appeared and seeking points of concurrence with other topics.
182
183 Table 3: Interviews conducted

	TOTAL	Academics	Practitioners	Decision-makers	Community actors
South Africa					
Cape Town	7	2	3	2	-
Durban (eThekwini)	8	1	2	4	1
Johannesburg	7	2	1	4	-
UK					
Birmingham	2	-	-	1	1
London	7	1	2	3	1

184
185 A number of limitations to the study should be noted. During the process of document collection and
186 analysis, reasonable efforts - such as testing of the search terms - were taken to ensure all relevant
187 documents were examined and that the corpus was a comprehensive as possible. There were
188 challenges in securing a diverse range of interviews across all of the cities, for example no community
189 actors were directly engaged with in the Johannesburg (including the immediate Gauteng City-
190 Region) and Cape Town, meaning that certain voices and perspectives are unevenly represented. The
191 results and discussion seek to mitigate these by drawing out major themes only and avoids drawing

192 strong inferences about specific groups. The selection of cities, while not focused solely on capitals,
193 is focused on major centres of population and economic activity. Future work might seek to deepen
194 the case insights by including more secondary cities.
195
196 **3. Results and discussion**
197 This section summarises findings from each city. Key points are presented in Tables 4-8, which
198 summarise: 'environmental context', 'environmental policy narratives', and 'green infrastructure', with
199 the latter broken down into sub-themes introduced in Section 2.ii b, abbreviated to: 'use', 'utility' and
200 'integration'. The tables are followed by more a detailed discussion for each city and the section ends
201 with an overarching summary.
202
203 **3.i South Africa**
204 In South Africa the broad national context for environmental policy is set out in the Constitution of the
205 Republic of South Africa (1996) (24:2): "to have the environment protected, for the benefit of present
206 & future generations, through reasonable legislative & other measures". Documents relevant to the
207 urban environment set out the aspirations for sustainable development and infrastructure planning,
208 including the National Framework for Sustainable Development (Department of Environmental Affairs
209 and Tourism, South Africa, 2008) and the National Infrastructure Plan (Presidential Infrastructure
210 Coordinating Commission, 2012), though these documents make little direct reference to green
211 infrastructure or related terms. The South African National Department of Environmental Affairs and
212 South African National Biodiversity Institute (SANBI) have consistently promoted the idea of
213 "restoring, maintaining, and enhancing existing ecosystems for the services they provide to society"
214 (Culwick et al., 2016; Driver et al., 2011) and The National Development Plan 2030 speaks of
215 "Sustaining South Africa's ecosystems and using natural resources efficiently", referencing "green
216 growth" and "green economy" (National Planning Commission, 2012).
217
218 **a, Cape Town**
219
220 Table 4: Key points – Cape Town

Environmental context	35% green cover (Husqvarna, 2019) The city sits within the smallest of the six global 'Floral Kingdoms', recognised by UNSECO as a world heritage site (UNSECO, n.d. accessed 2020), with diverse and unique biodiversity. Key green and blue spaces include coast, lakes, natural spaces and parks. Recent history of extensive droughts (Sousa et al, 2018).
Environmental policy narratives	*Narrative: 'Ecological infrastructure'* Cape Town's environmental policy focusses strongly on its rich and unique biodiversity and on specific challenges such as water management for supporting local populations and a large tourist base.
Green infrastructure	Documents and respondents defined green infrastructure in quite specific terms, outlining a range of features and benefits with a focus on services and functional capacities such as flood attenuation, waste absorption, air and water purification, resource provision, and recreational and cultural benefits (City of Cape Town, 2016)
Use	Green infrastructure was not seen as a common terminology due to, amongst other factors, a lack of (shared) meaning. 'Ecological Infrastructure' was seen as a more familiar and preferred term (City of Cape Town, 2017).
Utility	Emphasis was placed on the 'blue' element of green infrastructure. Those who employed the term valued its 'holistic' role.
Integration	The City of Cape Town Environmental Strategy (2017) and Integrated Development Plan (City of Cape Town, 2016) refer directly to green infrastructure.

Cape Town is the second largest city in South Africa. The contemporary city was founded in its current location in 1652, an important port developing rapidly into a major urban settlement. The city grew at a rate of 2.6% per annum between 2000 and 2018 (United Nations, 2018) remaining an important focus of industry, trade, commerce and tourism. Cape Town has 35% green space (Husqvarna, 2019), with 21% of urban green space covered by trees, and is renowned for its diverse and unique biodiversity[1] (UNSECO, n.d. accessed 2020). As a sub-tropical, coastal city, with large areas built on low-lying land, Cape Town is particularly susceptible to flooding caused by sea level change as well as other impacts related to climate change (such as fires) and exacerbated by increasing urbanisation (such as water shortages) (Anderson and Elmqvist, 2012; Sousa et al, 2018).

Green infrastructure appears as a minor reference in a range of local policy contexts including the Western Cape Government's 'Green is Smart: Western Cape Green Economy Strategy Framework' (Western Cape Government, 2013) (2 references), Green Economy reports 2015 (2 references) and 2016 (1 reference) (Western Cape Government 2015, 2016) and the City of Cape Town's Integrated

[1] It should be noted that some of the key natural tourist attractions and habitat areas of Cape Town are not owned or managed by the city / municipality but by other entities (e.g. South African National Parks, in the case of Table Mountain) with obvious limitations on the extent to which they are a locus of city-level policy

Development Plan (5 references) (City of Cape Town, 2016) and Environmental Strategy for Cape Town (City of Cape Town, 2017) (1 reference), which defines green infrastructure in quite specific terms, outlining a range of features and benefits: 'nature reserves and the Biodiversity Network, parks, public open space, rivers, wetlands and the coast… flood attenuation, waste absorption, air and water purification, resource provision, and recreational and cultural benefits' (City of Cape Town, 2016). These benefits were highted as critical to broader policy concerns around improving quality of life, addressing inequality and sustaining economic development. The work of the South African National Biodiversity Institute (SANBI) was seen as key in increasing the visibility of ecological infrastructure and green infrastructure in decision-making in the city.

Many interview respondents noted that green infrastructure is not a common terminology in Cape Town and within the planning context, in particular, some commented that it was not really often used due to a perceived lack of (shared) meaning. 'Ecological Infrastructure' was seen as a more familiar and preferred term (26 references in the Environmental Strategy for Cape Town (City of Cape Town, 2017)) meshing with a policy focus on the exceptional quality and diversity of the local flora and fauna. As a coastal city, and one which has suffered unprecedented droughts and water shortages since 2015 (Sousa et al, 2018), emphasis was placed on the 'blue' element of green infrastructure and those who employed the term valued its holistic role in communicating the importance of landscape form and function to delivering blue ecosystem services. Green infrastructure appeared in a number of documents setting out aspirations for future research and development in planning and policy for urban green space in Cape Town e.g. Cilliers and Siebert, 2012. In this sense, green infrastructure was seen as part of an 'enabling environment' for the design of new policy and investment criteria which prioritise investment in parallel to the natural environment. The Western Cape Green Economy Strategy Framework (Western Cape Government, 2013) sets out the idea that 'implemented correctly', ecosystem management would: 'create thousands of job opportunities. It will also expand the base of green infrastructure that offers more sustainable and cost-effective solutions to, for example, mitigation of flooding and coastal storm surges.' Opportunities for increasing the use of a green infrastructure framing were seen in sustainable design and development, linking to ideas of green procurement and sustainability within

supply chains which are wider policy priorities for the city. Many respondents noted that the area of environmental policy and planning had 'high political control' and influence in the city and that green infrastructure in this case could provide a means of bridging environment and other policy issues.

B, Durban (eThekwini)

Table 5: Key points – Durban (eThekwini)

Context	60% green cover (Husqvarna, 2019) Native vegetation still exists in and around the city, particularly along the coast. Key green and blue spaces include coast, lakes, natural spaces and parks (eThekwini Municipality, 2018). Recent history of significant flood events (Anguelovski et al., 2011).
Environmental policy narratives	*Narrative: 'Climate change, adaptation, mitigation'* Durban (eThekwini)'s environmental policy is framed heavily around potential risks from, and measures to respond to, climate change.
Green infrastructure	Policy documents referencing green infrastructure did not provide specific definitions. Interviews highlighted a range of topical and functional perspectives specifically parks, nature patches and rivers and the significance of landscape-scale thinking.
Use	Used more commonly within fields linking to planning, water, energy and waste. Seen as a 'technical terminology', reserved for specific technical use.
Utility	Noted utility at the interface with hard / built infrastructure and the need to indicate equivalence with grey infrastructure in terms of both social benefits and environmental benefits.
Integration	No key policy documents refer directly to green infrastructure. Analogous cases made implicitly through 'ecological infrastructure', 'ecosystem services' and links to the 'green economy'.

Durban (eThekweni) is the third largest city in South Africa. The city was formalised in its current location in 1844, already a major strategic port. The city grew at a rate of 1.0% per annum between 2000 and 2018 (United Nations, 2018) as an important focus of industry, trade, commerce and tourism. At 60% green cover, Durban was identified as the greenest city in the world in 2019 by the Husqvarna Urban Green Space Index (Husqvarna, 2019), with 42% of urban green space covered by trees. Durban is a noted biodiversity hotspot, with significant native vegetation in and around the city, particularly along the coast. As a sub-tropical, coastal city, Durban is particularly susceptible to high temperatures, drought, flooding, sea level change and other climate change related impacts (Anguelovski et al., 2011).

The Integrated Development Plan for Durban (eThekwini Municipality, 2017b) provides environmental development guidance, but does not explicitly mention green infrastructure, referring instead to 'ecosystem services' (32 references) and 'ecological infrastructure' (17 references). The Resilience Strategy (eThekwini Municipality, 2017a) also focusses on these two terms (9 and 3 references respectively), which have been progressively embedded in urban environmental policy in the city since at least 2004 (Roberts and O'Donoghue, 2013; Roberts, 2008) using the lens of climate change adaptation and mitigation. Green infrastructure as part of a climate change policy responses, to promote adaptation, was noted by interview respondents, recognising particularly its ability to simultaneously communicate a range of different benefits including: climate change adaptation, rainfall / storm water management, reducing building heat, improving biodiversity outcomes and providing useful plants (such as medicines) and contexts such as parks, nature patches and rivers. Policy documents from Durban did not provide specific references to, or definitions of, the term green infrastructure and interview respondents, particularly those in planning and decision-making, also often referred to it in parallel / analogue with ecological infrastructure, ecosystem (goods and) services and links to the green economy. The work of the Environmental Planning and Climate Protection Department was seen as key institutional champion, increasing the visibility of ecosystem service, ecological infrastructure and green infrastructure in decision-making in the city (Roberts, 2008).

Green infrastructure was seen by some interview respondents as pervasive within fields linking to planning, water, energy and waste. It was marked out by some as a problematic term that did not covey a specific meaning, or as 'technical terminology' reserved only for specific technical use. Academic documents focussing on Durban also noted the presence of green infrastructure in the planning domain and highlighted potential opportunities to broaden this lens to move the environmental policy narrative forward to encompass wider considerations of biodiversity and ecosystem services for addressing issues as diverse as social justice e.g. Shih and Mabon, 2017.

Interview respondents noted the particular utility of using a green infrastructure framing at the interface with hard / built infrastructure and their sense of an ongoing need to understand

relationships with grey infrastructure in terms of both social benefits and environmental benefits. This was paralleled with a number of considerations that help to equivalate green infrastructure as 'infrastructure' to further its policy integration, uptake and effective outcomes, such as the idea of 'asset management' and the need for a register of assets, ensuring ongoing investment and maintenance and recognising that natural services are not 'free services'. Making the business case for green infrastructure and potential job creation was also a key point of discussion for respondents, once again acknowledging a perceived capacity to link environmental issues to broader social and policy concerns. Specific challenges for using a green infrastructure framing in Durban included the risk of using policy narratives that appear to prioritise environmental issues in light of more pressing social issues such as poverty, jobs and housing, though respondents noted that many of these issues are often closely linked to green infrastructure outcomes.

c, Johannesburg (including the immediate Gauteng City-Region)

Table 6: Key points - Johannesburg

Context	42% green cover (Husqvarna, 2019) The city has a sub-tropical intercontinental climate with marked wet summers and dry winters seasons. Key green and blue spaces include lakes, natural spaces and parks and a large urban forest consisting mostly of introduced species (City of Johannesburg, 2008). Environmental challenges linked to the city's industrial past and current growth, include soil, water and air pollution and increasing water scarcity (Schäffler and Swilling, 2013).
Environmental policy narratives	*Narrative: 'Green assets and infrastructure'* Johannesburg's environmental policy is heavily framed around environmental remediation and appreciation and use of its natural assets to improve access to benefits and services.
Green infrastructure	Policy documents defined green infrastructure broadly, appreciating a range of different features and benefits, with clear links to social benefits.
Use	Used commonly across academic, local and provincial government settings, less so in planning. Increasingly familiar as a term, though still lacking a shared meaning between actors.
Utility	Highlighted as a key means for informing policy by which environmental and social progress can be achieved linking to critical policy areas of economy, housing etc.
Integration	City of Johannesburg Metropolitan Municipality Spatial Development Framework 2040 (City of Johannesburg, 2016) and Integrated Environmental Management Policy (2005) explicitly mention 'green infrastructure'.

Johannesburg is the largest city in South Africa. The city was founded in its current location in 1886 following the discovery of gold in the area, leading to a period of rapid growth and development. The city grew at a rate of 3.3% per annum between 2000 and 2018 (United Nations, 2018) as an important focus of industry, trade, business and commerce. Prior to the 1880s, the landscape of the city 'was characterized by savannah grassland, scattered bushveld, and some native woodland areas' (Schäffler et al, 2013). Today Johannesburg has 42% green cover (Husqvarna, 2019) and 'is home to an extraordinary ecological asset, what is claimed to be the world's largest urban forest, which according to the City is said to have grown to 10 million trees' (City of Johannesburg, 2008 in Schaffler and Swilling, 2013). As a sub-tropical, intercontinental city, Johannesburg is particularly susceptible to droughts, flooding and other climate change impacts influencing the severity and predictability of seasonal rainfall (van der Bank & Karsten, 2020)

The City of Johannesburg Metropolitan Municipality Spatial Development Framework 2040 (City of Johannesburg, 2016) explicitly mentions 'green infrastructure' (15 references) as a focus area across many policy domains: 'preserving green infrastructure and maximising its value for the city, including growing the economy, creating jobs and providing food and other products'. It defines green infrastructure by outlining a range of features and benefits that include: 'provisioning services that relate to the products derived from an ecosystem, including food, fibre and fuel, genetic resources, medicines and pharmaceuticals'. The City of Johannesburg's Integrated Environmental Management Policy (City of Johannesburg, 2005) also explicitly mentions green infrastructure (4 references).

Several sources highlighted green infrastructure as a 'basic natural element, that nature provides', 'seen as parallel and complimentary' to built infrastructure and as a grey infrastructure analogue: 'these assets form an infrastructure network providing services and strategic functions in the same way as traditional grey infrastructure' (Culwick et al., 2016). Some respondents noted that green infrastructure is a relatively familiar term, especially in academic, local and provincial government settings, though less so in planning. It was often described as being without a single definition, where actors using the term were not always sure if they were talking about the same thing. Definitions variously included or excluded human-built infrastructure like green roofs and walls,

others included green technologies like solar energy alongside bio- and geological services. Some respondents noted that in their view the specific definition of term itself didn't matter, as long as the overall objective was for a sustainable outcome. The work of the Gauteng City-Region Observatory (Schäffler et al, 2013; Culwick et al, 2016)) was seen as key in increasing the visibility of green infrastructure in decision-making in the city.

Much academic work on green infrastructure in Johannesburg focussed on the importance of aligning green infrastructure issues with social issues, seeing this as a way to directly address multiple challenges simultaneously. Schäffler and Swilling (2013) argue that 'without aligning ecological and economic goals, many pro-poor development arguments neglect the essential role that local ecosystem services can play in wider development' (Sattherthwaite, 2008; Swilling, 2007 in Schäffler and Swillling, 2013)'. This was also captured in the Spatial Development Framework 2040: 'environmentally sensitive and open areas pose unique, sometimes-overlooked opportunities to development. It can create unique green infrastructure solutions, socio-economic, agricultural, educational and tourism-based opportunities' (City of Johannesburg, 2016).

Attempts to integrate green infrastructure in to mainstream thinking and to directly influence (environmental) policy narratives in the city included an attempt to move away from viewing green assets as luxury items or 'nice-to-haves' and bridge the 'historical separation between ecological investments and mainline infrastructure planning' (Schäffler et al., 2013). Coming back to, in the words of Lennon (2015), a "narrative of necessity". Some respondents called for green infrastructure to be seen in the same way as other built infrastructures, as Schäffler and Swilling (2013) note: 'so that they can be designed and developed to function as a whole, rather than as a set of separate unrelated parts' (Barthel et al., 2005; Benedict and McMahon, 2002 in Schäffler and Swilling, 2013). This 'infrastructure' lens appears to have been particularly key in aligning green infrastructure with the critical issues of service provision in the city.

3.ii UK

385 The UK national context for environmental policy is quite well developed and in the process of being
386 renewed through a new Environment Bill, which sets out a high-level context at country-level and at
387 the draft stage (December 2020) did not explicitly mention 'green infrastructure', 'ecosystem
388 services' or 'green space'. Policy documents highly relevant to the urban environment include the
389 National Planning Policy Framework (Ministry of Housing, Communities and Local Government,
390 2012, 2018, 2019), which does directly reference green infrastructure, and its associated National
391 Planning Practice Guidance documents (Ministry of Housing, Communities and Local Government,
392 2014-2021). The UK Government's 25 Year Environment Plan (HM Government, 2018) endorsed a
393 'natural capital approach' to managing the environment with explicit reference to green
394 infrastructure. Specific areas of emerging interest include the growing linkages of green
395 infrastructure with health as explored in the Marmot Review (Marmot, Allen & Goldblatt, 2010).
396
397 **a, Birmingham**
398
399 Table 7: Key points - Birmingham

Context	>20% green cover (Birmingham City Council, 2017) Vegetation largely cleared during urban development and expansion. Surrounded by semi-natural vegetation and agricultural land. Key green and blue spaces include canals, rivers, lakes, natural spaces and parks (Birmingham City Council, 2017). Increasingly at risk of changes in rainfall, flooding and increasing summer temperatures (Birmingham City Council, n.d. accessed 2020)
Environmental policy narratives	*Narrative: 'Natural capital and ecosystem services'* Birmingham was an early adopter of natural capital accounting at the city level and this is captured in much of the ongoing policy discourse on the urban environment (Hölzinger & Grayson, 2019).
Green infrastructure	Policy documents defined green infrastructure broadly, appreciating a range of different features and benefits for environment and planning.
Use	Respondents cited their use of the term with politicians and citizens in the city. 'Ecosystem services' and 'natural capital' were also frequently used terms, sometimes in preference to green infrastructure.
Utility	The Birmingham Plan highlights the importance of 'linking with future developments and seeing green infrastructure as a 'network'' contributing to infrastructure provision in particular (Birmingham City Council, 2017).
Integration	Included in the Birmingham Plan 2031 (Birmingham City Council, 2017) and Birmingham Green Living Spaces Plan (Birmingham City Council, 2013).

400
401 Birmingham is the UK's second largest city. It was founded in its current location in the 12th century
402 AD and has grown significantly since the 18th Century; initially due to its agricultural wealth, followed

by rapid growth during the early industrial period based on its historic importance for developments in physical sciences and engineering feeding the industrial revolution, with local industries including metalworking. The city grew at a rate of 0.7% per annum between 2000 and 2018 (United Nations, 2018). Birmingham is: ‘one of Britain’s greenest [cities] with more than one fifth of its area consisting of parks, nature reserves, allotments, golf courses and playing fields, many of which are linked by rivers, watercourses and a significant number of canals’ (Birmingham City Council, n.d. accessed 2020b). The city is particularly susceptible to flooding as well as other impacts related to climate change and increasing urbanisation (Birmingham City Council, n.d. accessed 2020).

Birmingham was the first city in the UK to undertake a city-wide natural capital account (Hölzinger & Grayson, 2019) and as such has been employing the language of ‘natural capital’ and ‘ecosystem services’ since at least 2013 (Birmingham City Council, 2013). Multiple policy documents from Birmingham refer to green infrastructure directly, including the Birmingham Plan 2031 (Birmingham City Council, 2017) (32 references) and Green Living Spaces Plan (Birmingham City Council, 2013) (20 references), defining it broadly, outlining a range of specific features and benefits and describing it as a means to ‘distinguish’ the city: ‘green infrastructure includes landscapes, natural environment, biodiversity and geological features which make Birmingham distinctive...’ (Birmingham City Council, 2017). Green infrastructure was often used as a secondary term to ‘ecosystem services’, with ‘natural capital’ also being widely used. Use within particular communities of practice was highlighted, but across the respondents the communities of use defined ranged from citizens to politicians, indicating different perceptions of the utility of the term across and between different communities of use in the city.

The Green Infrastructure Evidence Base for Birmingham (May, 2010) provides clear context to green infrastructure in the city, including examples of interventions, multiple framings of benefits and links to specific technologies. It also highlights documentary research on the economic, social and environmental benefits of green infrastructure from a variety of sources, including work within Birmingham City Council. The Birmingham Plan 2031 highlights the importance of ‘linking with future developments and seeing green infrastructure as a 'network'’ (Birmingham City Council, 2017). The

plan outlines a green infrastructure contribution to 'high quality infrastructure' provision, with particular links to climate change adaptation, water management and specifics around urban forestry, which are all viewed as broader challenges for the city. The Green Living Spaces Plan describes a green infrastructure's 'fit with high-level policy objectives' for planning, environmental sustainability and green economy and speculates an implementation and funding model based on evidence 'informing policy, informing delivery' (Birmingham City Council, 2013).

b, London

Table 8: Key points - London

Context	41% green cover (Husqvarna, 2019) Large areas of vegetation largely cleared during urban development and expansion. Key green and blue spaces include lakes, canals, rivers, parks, forests and a range of green spaces both historic and recent (GiGL n.d. accessed 2020). Increasingly at risk of flooding and increasing summer temperatures (Jones Climate + Sustainability Consulting, 2019; London Climate Change Partnership, 2002).
Environmental policy narratives	*Narrative: "London National Park City"* London has a range of protected historic spaces and new landmark developments and is trying to build a global reputation as a green city. One of the key narratives supporting this is the concept of London as a 'National Park City' (London National Park City, n.d. accessed 2020).
Green infrastructure	Policy documents defined green infrastructure broadly, appreciating a range of different features and benefits for environment and planning, linking to many areas of urban development.
Use	Green infrastructure seen as a recent, and not yet common term. Used by professionals (practitioners, developers, master planners etc.) but not in public contexts.
Utility	Highlighted as a critical element of infrastructure planning in a growing city.
Integration	Green infrastructure is a central component of the London Plan (Mayor of London, 2016) and London Environment Strategy (Mayor of London, 2018).

London is the largest city in the UK. The city was founded in its current location in at least the 1st Century AD, due to its strategic position in the south of the country and on the River Thames, sustaining trade and industry. The city grew at a rate of 1.2% per annum between 2000 and 2018 (United Nations, 2018). London has a range of green and blue spaces, variously quantified at 41% green (Husqvarna, 2019) and 'roughly 47% of Greater London is 'green'' (Greenspace information for Greater London (GiGL), 2019). In 2019 London was declared a 'National Park City', the first of its kind, following a local grassroots campaign to recognise and collectively champion its distinctive and

diverse natural and human environments. The 'National Park City' framing is used extensively throughout the London Environment Strategy (Mayor of London, 2018). Largely built on flat, low lying land within a major river catchment, London is particularly susceptible to heatwaves, flooding, sea level change and other impacts related to climate change and increasing urbanisation (Jones Climate + Sustainability Consulting, 2019).

Many reports and policy documents from London reference green infrastructure, including the London Plan (59 references) (Mayor of London, 2016) and Environment Strategy (106 references) (Mayor of London, 2018) broadly, describing it as a 'multifunctional network' and outlining a range of specific features and benefits: 'including, but not limited to, biodiversity; natural and historic landscapes; culture; building a sense of place; the economy; sport; recreation; local food production; mitigating and adapting to climate change; water management; and the social benefits that promote individual and community health and well-being.' (Mayor of London, 2016). Some respondents noted that green infrastructure was not commonly used yet, some referring to its emergence in the early 2010's, and that it was still used only by specific people or groups, particularly 'professionals' (practitioners, developers, master planners etc.) but not in public contexts. Issues around its use reflected the idea that its meaning is not widely agreed and that other terms including 'natures / natural assets' are also used. Some saw the potentially broad scope of green infrastructure as useful, with benefits for uniting environmental and social priorities to support narratives around a range of health and environment challenges under one umbrella term, in the same way as the 'London National Park City' framing. The All London Green Grid (ALGG) Supplementary Planning Guidance (Mayor of London, 2012) reflects that: 'the term "Green infrastructure" may sound odd, but given the scale and range of benefits these spaces give our city and its neighbourhoods, it is vital we see them as being as integral to the capital's metabolism'. The work of the ALGG, GiGL and Greater London Authority's Green Infrastructure Task Force (Greater London Authority, 2016) was seen as key in increasing the visibility of green infrastructure in decision-making in the city.

Green infrastructure appears as a: 'generic framing for green spatial development of London' (Greater London Authority, 2016) and is seen to have influence in planning decisions and

development proposals as a 'compliment' to grey infrastructure (Mayor of London, 2012) particularly Sustainable Urban Drainage Systems (SuDS). Respondents within the planning profession specifically spoke of green infrastructure as ‘greening the grey’. Academic work on the city highlighted: ‘delivery of transport, green infrastructure, energy infrastructure and circular economy objectives of the London Infrastructure Plan 2050 (Mayor of London, 2015) and… a broader long term strategy for investment in green infrastructures and technologies’ as being key considerations (Miciukiewicz and Moore, 2015) placing green infrastructure within and alongside the policy narratives supporting urban development at the highest level.

3.iii Narratives of urban green infrastructure

All of the cities studied showed evidence of integrating elements of ‘green infrastructure’ into their urban environmental decision-making. While specific definitions varied, most included one or more elements of green infrastructure being: ‘networks’, ‘high-quality green and blue areas’ and ‘providing valuable, tangible benefits to both the natural environment and to human populations’, with a critical role in supporting and maintaining rapidly growing and evolving urban communities. To this end, this analysis echoes the findings of Matsler, Miller and Groffman (2021), framing green infrastructure as a “win-win land use solution”, which retains “explicit focus on environmental gains”. A note of moderation was offered by a respondent who saw green infrastructure as a problematic and potentially “dangerous” term in its reductive framing of the environment, but at the same time recognised how effective it has been in ‘speaking’ to audiences in decision-making in particular embedding green issues into the broader policy narrative. This echoes some strands of academic discourse on green infrastructure as a potentially useful but divisive term (Wright, 2011). The lack of a shared definition for green infrastructure was seen as potentially limiting and respondents cited a desire for definitions and guides for understanding (quantifying and qualifying) and communicating the multiple benefits of green infrastructure in the urban setting. However, all cities had engaged with the term in spite of this fact, playing to its strengths where they saw them and building their own cases to amplify these in the context of the prevailing policy narratives of the city. In this light, green

infrastructure as a term could certainly be described as “flexible and robust” as in Matsler et al. (2021).

Urban environmental policy narratives varied significantly across the case study cities and this paper has attempted to identify and describe them in a succinct way: Cape Town (ecology and biodiversity), Durban (climate change mitigation and adaptation), Johannesburg (assets, services and infrastructure), Birmingham (natural capital) and London (the national park city). As global south cities with a long urban history and rapid contemporary growth, Cape Town, Durban and Johannesburg all have clear policy priorities for economic development and social equality across key areas of service provision (water, waste, food etc.), health, housing and employment. Green infrastructure narratives across the cities were clearly tied back to these priorities in specific ways (e.g., green job creation in Durban) or generally through the development of narratives that highlight the complimentary and supporting role that the environment plays in addressing all of these urban challenges. Priorities for London and Birmingham also include service provision (particularly focussing on water and air quality) and the creation and maintenance of healthy and equitably served populations. The ways in which green infrastructure had been integrated was clearly influenced by the environmental and wider policy narratives of the cities in question: Cape Town - enabling planning and management of natural open spaces and natural systems, understanding ecological patterns, service provision, Durban - climate change response and adaptation, protection and management of natural ecosystems, Johannesburg - sustainable development, environmental remediation, value capture, green economy, Birmingham - preservation of distinctive natural and built environment, value capture and London - cleaner and greener urban development, building global reputation as a green city.

Observing the various ways in which green infrastructure co-exists with the urban environmental policy narratives of the five cities allows us to see a spectrum of approaches, from being fully adopted and engrained across policy at a range of levels (London) to its dominant use in particular areas such as planning (Durban) to its implicit presence within the purview of other preferred terms (‘ecological infrastructure’ in Durban and ‘natural capital’ in Birmingham). Specific factors promoting

the use of ‘green infrastructure’ as a framing within the urban environmental policy narratives of the cities are difficult to pin down in this limited study, but appear to include (in non-priority order): thought leaders, advocates and champions increasing the visibility of green infrastructure (e.g. GCRO in Johannesburg, London National Park City, ALGG, GiGL and the Greater London Authority in London) and a good fit with existing narratives (e.g. Environmental Planning and Climate Protection Department in Durban, in climate change mitigation). Factors limiting its use in the same contexts are, by the same turn, competition with existing narratives, especially those that already take a holistic approach (e.g. ‘natural capital’ in Birmingham, ‘ecological infrastructure’ in Cape Town). Where this is the case, there are opportunities to “translate the GI message as a positive development within these wider holistic initiatives.” (Hislop, Scott and Corbett, 2019).

A common justification for the inclusion of green infrastructure in the narratives across all of these cities was the capacity that it has to highlight a range of diverse and interconnected benefits. This aligns strongly with an increasing need for environmental policy to respond to a complex and increasingly urban world, moving away from traditional environmental concerns to more integrated approaches. For the cities studied these included: Cape Town - tourism, recreation and culture, job creation; Durban - infrastructure and building services, health; Johannesburg - social and economic benefit, health, and transport; Birmingham - urban planning, economic growth; London - health and wellbeing, liveability, transport and energy infrastructure and circular economy objectives. The cities have all recognised, in their own ways, the benefits of environmental policy approaches that aim to bring together broader concerns across environment, society and economy and the most prevalent and persistent narratives show this character. Bevan et al (2020) note that successful narratives for a changing world often need to be holistic and encompassing, to ensure that a broad range of knowledge and perspectives can be captured and recognised. In the words of Frantzeskaki (2019): “an inclusive narrative of mission can be an integration ‘tool’ in seeking consensus, attract support and salience in policy agendas for nature based solutions.” In this sense the broad scope and malleability of a term like green infrastructure can be a significant strength.

While it is beyond the core scope of this paper, it is worthwhile noting that some elements of the observed dynamics in adoption of green infrastructure into city-level policy, is mimicked at country- and regional-level. As noted in the introduction, the term and approach has largely evolved in Europe, North America and Australia, but is currently being increasingly adopted in a range of other global contexts leading to a range of interpretations and key foci (Lindley et al., 2018; Matsler et al, 2021; Matsler, Miller & Groffman, 2021). Further work may help to further contextualise these city-level insights within the country- and regional-level contexts of policymaking and implementation.

4. Conclusion

The five cases included in this paper provide insights into the ways in which cities have captured and adapted green infrastructure as a term and as an approach to fit their own policy and planning needs. This work has demonstrated that terms like green infrastructure can gain traction for different reasons in a wide range of urban environmental policy contexts. One of the key factors in the uptake of this term is that it demonstrates enough utility and flexibility to mean many things to many people, while still conveying a general sense of progressive orientation towards the environment, economy and society.

This paper explored five environmentally, socially and economically distinct urban contexts, finding that the green infrastructure framing interacts in complex ways with existing environmental policy narratives and is adopted to a greater or lesser extent for decision-making purposes in line with factors including local advocates / champions, fit within existing policy narratives and the presence of strong alternative framings. As a still relatively recent introduction to the vocabulary of environmental policy, the full impact of green infrastructure on urban environmental policy is yet to be seen. This study supports a growing literature suggesting that it can be embraced in the policy narrative where cities are seeking a unifying lens for environmental concerns, social and economic development. While disparities in precise definition and application exist, it is clear that cities across a range of environmental, social and economic contexts are using the framing of green infrastructure across settings to try to progress issues in environmental management, urban planning, service

593 provision and infrastructure delivery. Insights from this work aim to support decision-makers in
594 these, and other, cities by highlighting opportunities and challenges in using the framing of ‘green
595 infrastructure’ in green space policy across a range of different urban contexts.

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