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Rethinking urban green infrastructure and ecosystem services from the perspective of sub-Saharan African cities.

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[Narrative Review]

Abstract: Urban green infrastructure and its ecosystem services are often conceptualised in terms of a predominantly western perspective of cities and their wider social, economic and environmental challenges. However, the benefits which are derived from urban ecosystems are equally – if not more – important in the cities of the developing world. Cities in sub-Saharan Africa are well known to be facing severe pressures. Nevertheless, despite the challenges of rapid population change, high levels of poverty and seemingly chaotic urban development processes, there are also tremendous opportunities. Realising the opportunities around urban green infrastructure and its benefits requires harnessing the inherent local knowledge and community innovation associated with a multitude of inter-connected urban social-ecological systems. Such systems are a powerful driving force shaping urban realities. Associated planning regimes are frequently lambasted as being either absent, weakly enforced, corrupt or wholly inappropriate. Much of this criticism is justified. However, it must also be recognised that decision-makers are frequently working in contexts which lack the scientific foundations through which their decision-making might be made more effective and complementary to bottom-up initiatives. The paucity of research into urban ecosystems in sub-Saharan Africa and the lack of development of

context-specific conceptual, theoretical and empirical foundations is a problem which must be addressed. Drawing on papers from a Special Issue centred on urban green infrastructure and urban ecosystem services in sub-Saharan Africa, we consider what concepts and frameworks are in use and what needs to be considered when framing future research. We also synthesise key messages from the Special Issue and draw together themes to help create a new research agenda for the international research community.

Key words: green infrastructure, ecosystem benefits, urban settlements, frameworks, review, Africa

Research highlights

- *A transdisciplinary research agenda & synthesis of key messages from our Special Issue*
- *Research on Africa's urban green infrastructure & its benefits uses many frameworks*
- *Not all frameworks currently recognise Africa's distinctive urban characteristics*
- *We propose a ten point list for developing novel, context-specific frameworks*
- *The few relatively well researched African cities are beacons for future activity*

1. Introduction

Forty years ago, Richard L. Meier identified the requirements for a ‘stable urban ecosystem’ in the developing world. For him, the urban ecosystem comprised all components of emerging cities, including their populations, food and transport systems, industry and commerce (Meier, 1976). His ideas were different to, but still aligned with, more recent ideas around urban green infrastructure (GI) and associated ecosystem ‘services’. The need to consider the interrelationships between people and the environment and urban areas as social-ecological systems is now well recognised (Pickett et al., 2011). In a world which is both more populous and more urban, these ideas are growing in popularity and importance. Nevertheless in some parts of the world, research and associated knowledge exchange on these themes remains limited (Elmqvist et al., 2013; Haase et al., 2014). There are many possible reasons, including ones which stem from differences in social, cultural, environmental and resource contexts. In sub-Saharan Africa (which we will hereafter refer to as Africa), a lack of institutional capacity and perceived relevance together with a whole gamut of ‘more pressing’ concerns ensure that priorities around urban green and blue spaces and the benefits that they bring to urban dwellers are commonly lost or never considered (Herslund, et al., 2017). For some, *“The notion that ecosystem services ...should form the foundation of city planning flies in the face of the current practice in almost every African city over the last century, where the resilience of the nature resource base has been taken for granted”* (Blanco et al., 2009, p. 240). Undoubtedly, this situation is not helped by the development of conceptual principles and practical examples based on very different urban settings than those characterising the Global South and where there are already robust criticisms of failures in urban planning regimes. Such failures are attributed to the tendency for planning regimes to exist as either legacy instruments from colonial times or imported models and frameworks which proved to be ill-suited to the emerging realities of urban

Africa (Anderson, Okereke, Rudd, & Parnell, 2013; Blanco et al., 2009; UN-HABITAT, 2014). In its 2014 State of African Cities report, UN-Habitat calls for a ‘radical re-imagining’ of current systems in order to inspire innovation, mitigate problems and harness benefits (UN-HABITAT, 2014). This begs the question of whether concepts like urban GI and ecosystem services are simply more of the same or whether they might form part of the foundation and inspiration for a revolution in thinking and action in African towns and cities.

Arguably, urban ecosystem services – as the beneficial ecosystem functions required for human wellbeing – are more important in the context of many African cities than anywhere else. Yet, it is in these contexts that research is particularly scant with a clear bias to South African cities (Cilliers, Cilliers, Lubbe, & Siebert, 2013; du Toit et al., 2018; Smit & Parnell, 2012). This is not to assume that no relevant research exists, just that much of it remains outside of the international peer-review literature (Cavan et al., 2012). Furthermore, there is a great deal of informal knowledge residing within local communities (Elmqvist et al., 2013). The papers in this Special Issue (SI) highlight the close relationships between urban populations and ecosystem services in Africa (e.g. Roy et al., 2018), the marked inequalities that exist in access to some services (e.g. McConnachie & Shackleton, 2010; McConnachie, Shackleton, & McGregor, 2008) and the very different status and diversity that associated green structures can have (e.g. Anderson et al., 2013; Cilliers et al., 2013). Although there are commonalities between the services which are provided in different cities the world over, in the context of urban Africa, there are also distinct differences (Davoren, Siebert, Cilliers, & du Toit, 2015; Shackleton, 2012). For example, urban agriculture provides a literal life-line for many of the poorest members of society in urban Africa (e.g. Abo-El-Wafa, Yeshitela, & Pauliet, 2017). However, the sheer pace of development in this part of the world is threatening the very existence of this productive green space and the ecosystem services

upon which the livelihoods and wellbeing of the urban poor largely depend (e.g. Lindley et al., 2013; Printz, Abo El Wafa, Buchta, & Pauleit, 2015).

The composition and extent of green structures themselves also affect the urban ecosystem services which are provided. Many African cities still retain significant remnants of native ecosystems and plant assemblages. Although often degraded, they provide a buffering function for natural hazards, e.g. in the case of mangroves for coastal flooding or native flora on wooded slopes and river banks in Addis Ababa (Cavan et al., 2012; Gómez-Baggethun et al., 2013), as well as safety-nets against economic and assets shocks (Sachikonye, 2014). Studies from South African cities in biodiversity hotspots of international importance (e.g. Cape Town and Durban) have indicated how ecosystem services of fragmented natural areas need to be assessed and valued to show their importance for inclusion in urban planning and management (De Wit et al., 2012; O'Farrell, Anderson, Le Maitre, & Holmes, 2012; Roberts, Boon, Croucamp, & Mander, 2005). However, rapid rates of development and lack of enforcement of regulations means that the continued availability of services cannot be guaranteed, even where their city-wide importance is well recognised in academic and policy circles (Anderson et al., 2013). Efforts to re-establish and protect native ecosystems are often in evidence but face pressures from environmental change, the demands of economic and political agendas and the lack of firm enforcement of plans, policies and regulations. However, there are some success stories and an ever-improving understanding of underlying issues and how they can be tackled (e.g. Herslund et al., 2017). This SI brings together further evidence generated from formal projects, published literature and from more informal knowledge bases, including some which have been built up over decades (Douglas, 2016).

The nature and extent of pressure from development is an obvious source of differences between urban areas in Africa and those in the Global North (du Toit et al., 2018). However, just as rapid change and urban expansion can lead to losses, there are also opportunities for establishing green structures and services which are rare, if not entirely absent, in developed cities. For example, the Addis Ababa City Beautification, Park and Cemetery Development Agency plans to establish multiple new parks across the city, though realising them in practice can still be a challenge (Assefa, 2013; Jemaneh, 2017). Initiatives in Addis Ababa include examples which have biodiversity and ecosystem services goals, including medicinal plant schemes and schemes involving the rehabilitation of the upper river catchments in the northern fringes of the city using biological and physical measures (Cavan et al., 2012; Yohannes and Elias 2017). Over the past ten years the schemes have helped to bring back the native flora (e.g. *Juniperus procera*, *Hagenia abyssinica*, *Rosa abyssinica*) using soil seed banks and enrichment plantations. In turn the improvements are helping to provide wider ecosystem services, for example several springs are reappearing and being used as potable water for nearby residents and holy water for followers of the Ethiopian Orthodox Church. Although not a specific theme in this SI, examples like this underline the importance of the connections between biodiversity and ecosystem services, something which may be particularly strong in Africa.

In concluding this SI, we complement the review of urban GI and ecosystem services in Africa used to open it (du Toit et al., 2018). Inevitably there is some overlap between our messages. However, here we also look back over the SI and reflect on what more the contributing papers reveal as a whole, assess what knowledge gaps remain and consider how gaps might be bridged in the future. Such an assessment involves thinking through the implicit assumptions behind the terms and ideas shaping this field of study. Through shining a light on implicit assumptions, it is

hoped that researchers will recognise them better and consider them more explicitly in future studies. Researchers will then be better placed to consider how to represent the specific contexts of diverse African cities more effectively, to address science, policy and practice challenges and to harness opportunities for maximum benefit.

The remainder of our paper is structured into two parts. Part 1 provides a brief summary of how notions of GI and ecosystem services have been developed and conceptualised. Notably, this draws from work which has been mainly carried out in the Global North. Part 2 considers what is learnt from the research presented in this SI through addressing three related questions:

- What does this SI further reveal about GI and urban ecosystem services in African cities?
- How have related concepts and frameworks been used and might be adapted to provide a better foundation for research and practice in African cities?
- How far does this SI help to address gaps and what future research agendas emerge?

2. Methods

Part 1 is informed by a semi-structured review of the academic literature. An overview of the terms urban GI and urban ecosystem services and some of the frameworks and ideas with which they are associated was developed from accessing 24 review papers published before 2017. Candidate papers were identified using the search term “review” with “framework” and with one of “urban ecosystem services”, “urban green infrastructure”, “social-ecological systems”, “urban ecology” “urban environment* planning” or “urban landscape planning”. Concepts are therefore extracted from papers explicitly aiming to frame issues around GI and urban ecosystem services. These papers can be expected to inform studies in the topic area of this SI. Papers were excluded where the review was primarily on empirical evidence and not on framings, centred on a

narrowly-defined thematic focus, e.g. green facades, and/or explicitly focussed on geographical settings demonstrably outside of the remit of this SI. From this shortlist, a snow-balling approach was used to identify additional key texts which were further supplemented with papers identified by each of the authors. A fully exhaustive and systematic review was beyond the scope of this particular article. The selection of papers drew on recognised protocols for systematic reviews but can only be considered partially systematic in this case (Pullin & Stewart, 2006). All literature searches were carried out using Web of Science to identify English-language sources in the peer reviewed, scientific literature. It is recognised that this may exclude influential sources not held within these sorts of bibliographic databases. Equally, there are variants in terms which may also have unintentionally excluded some sources, e.g. “ecological planning”. Given that our intention is to summarise the nature and foundation of terms and associated frameworks, these limitations are considered to be acceptable.

The review aims to provide insights into the theoretical basis upon which most current studies on African GI and ecosystem services are likely to be based. Due to a lack of review papers on frameworks explicitly and solely centred on urban GI and ecosystem services in African cities, there is limited reference to Africa in Part 1. This is not to imply that there is no theory, rather it notes that the theory does not appear to have been systematically reviewed as yet. By extension, it can be assumed that framings – whether standard or refined - tend to be identified on a case-by-case basis. Given these assumptions and limitations, the review then sets the scene for addressing the questions for Part 2. The questions were derived with reference to previous review papers (Binder, Hinkel, Bots, & Pahl-Wostl, 2013; Haase et al., 2014).

3. Part 1: Urban GI and urban ecosystem services as guiding frameworks – what the literature tells us.

There are numerous frameworks used to guide thinking in the complex, multi-faceted and transdisciplinary arena of urban GI and urban ecosystem services. As structured sets of concepts, assumptions and relationships, frameworks can be conceptual, analytical or process based, but all act as the foundation for understanding a particular view of reality (after Binder et al., 2013). Frameworks are therefore informed by disciplinary specialisms which reflect the particular world-views of researchers and their epistemological, ideological or contextual underpinnings. In other words they can be influenced by academic backgrounds and traditions, modes of knowledge generation, personal goals and mind-sets and socio-political and cultural settings. For example, urban areas can be seen as everything from ‘parasites in the biosphere’ (Odum, 1971, cited in Bolund & HunHammer, 1999) to opportunities for social reform (Ebenezer Howard, 1898, as discussed in Maruani & Amit-Cohen, 2007).

Despite this multiplicity – or perhaps because of it - there is now a concerted effort to accommodate different perspectives around urban GI. This is certainly a work in progress, but a range of frameworks have evolved which consider urban areas to be firmly social-ecological systems of one form or another. One element of this convergence process has been nicely summarised as a meeting between ecological and ecology-related schools of thought with planning and planning-related schools of thought so that the former move from ecology *in* the city to ecology *of* the city and the latter from planning *of* the city to planning *in* the city (Gómez-Baggethun et al., 2013; Pickett et al., 2011). The concept of GI and its ecosystem services and the ever closer ties they make between landscape ecology and spatial planning might then be seen as a logical outcome of this process (Gómez-Baggethun et al., 2013). Another element of the convergence process towards social-ecological systems is, of course, that ever closer ties are made between people and ecosystems. The underlying thinking becomes inherently orientated to an anthropocentric view given that human health and wellbeing tends to be emphasised over

ecosystem ‘health’, i.e. the conservation, maintenance and enhancement of biodiversity and ecosystem functionality (Tzoulas et al., 2007). Even as a supposed human-orientated construct, evidence suggests that key principles remain under-developed. For example, from 84 ecosystem service frameworks published 1987-2014, 62% did not consider human health and only a quarter considered interactions between human and ecosystem health (Ford, Graham, & White, 2015).

The traction of this particular terminology has been aided considerably by its adoption by major initiatives such as the Millennium Ecosystem Assessment (MEA) and The Economics of Ecosystems and Biodiversity (TEEB) (TEEB, 2011; Rall, Kabisch, & Hansen, 2015). Such work makes the economic principles that informed the development of the concept of ecosystem services all the more explicit (Costanza et al., 1997; de Groot, 1987). For some, this is a strong point of contention, but by no means the only one. Schroter et al. (2014) discuss no fewer than seven arguments against the use of ecosystem services as a concept. Arguments include: the prioritisation of people over ecosystems; the commodification of nature and encouragement of exploitative practices; and the promotion of a framework which is at the same time vague and also normative. These concerns have not halted the growing popularity of the term in academic or practitioner circles, with several national and supranational assessments in Europe already adopting ecosystem services assessment and associated economic valuation methods to help to fill a void in how to meaningfully connect issues around ‘nature’ with everything else – i.e. in prevalent socio-political contexts (Rall et al., 2015). Developing appropriate modes of valuation as well as evaluation of urban ecosystem services are still very much an area of current research, e.g. to recognise the limits of monetary valuation, the range of ‘value domains’ involved and ways of recognising the value of biodiversity (Gómez-Baggethun & Barton, 2013; Knippenberg et al., 2015). Complementary concepts such as bio-cultural diversity have also been proposed to complement ecosystem services (see Buizer, Elands, & Vierikko, 2016). The concept highlights

the inter-connectedness and inter-dependencies of cultural and natural systems and is highly relevant to this review due to its provenance, i.e. developed from research into livelihoods and nature conservation in the Global South.

These issues are pertinent for research into GI and associated ecosystem services for Africa cities as they have implications for the suitability of its framing. In some cases the assumptions may not fit well with the contexts of their application or they may have particularly problematic consequences for onward use. For example, how far is an emphasis on traditional planning processes helpful and what sort of problems may result from an emphasis on economic costing models in a quick moving, informal economy with few safeguards on development in ‘protected’ areas?

The Inter-governmental Platform for Biodiversity and Ecosystem Services (IPBES) - itself a science-governmental partnership – is now a major proponent of ‘ecosystem services’, albeit with an evolution of some of the terms and language, e.g. to fit with traditions outside of western scientific culture. This latter distinction is important, though, when it comes to framing assessments which value the range of contexts within which knowledge is produced and learning applied (Díaz et al., 2018). Therefore, how biodiversity and ecosystem services are being interpreted for IPBES (Díaz et al., 2015; 2018) is a major consideration. The second important aspect here is the emphasis on biodiversity. Some argue that the role and value of biodiversity, both for conservation and also benefits to urban dwellers is still only weakly understood (Shwartz, Turbe, Julliard, Simon, & Prevot, 2014) and ‘green planning’ approaches should not be at the expense of the promotion of interventions at the micro-scale that address biodiversity, multi-functionality and wider human benefits. There is a case for conservation in urban areas but the main motivations are somewhat unclear or not currently fully tested, such as for *in situ*

species conservation, for migration through corridors and stepping stones, for benefits to people through cultural and other ecosystem services or for conservation education. Some of these motivations echo how the framing of conservation has changed over time, how multiple interpretations now co-exist (Mace, 2014) and how they reflect a range of legitimate perspectives. Conceptualising urban social-ecological systems requires an assessment of what system is in focus and how it can be understood (Gómez-Baggethun et al., 2013). In the context of this SI, it is interesting to explore how far authors analyse the term ‘urban’ and what terms and ideas are used to understand and represent African urban green and blue landscapes. In the wider literature some discussions are framed around ‘open space’ (Maruani & Amit-Cohen, 2007), others ‘green and blue’ space (Bolund & HunHammer, 1999; Gómez-Baggethun et al., 2013). Such spaces are often translated into land units, frequently as discrete and bounded land parcels (Gill et al., 2008; Huang et al., 2015; Pickett et al., 2011). Land parcels are used for several reasons. Firstly, they make logical sense from the perspective of land use planning regimes and the historical urban development processes which generally prevail in the Global North. Secondly, bounded land parcels facilitate the development of indices that draw on a variety of existing databases and allow social-ecological processes to be considered together, e.g. in ecosystem service ‘bundles’ (Elmqvist et al., 2013; Pickett et al., 2011). Finally, they provide a way for knowledge and knowledge generation to be translated into a form assumed to be suitable for application in practice, i.e. meaningful for practitioners. Delineation of appropriate units and the consideration of units also helps to make the need to consider spatial scale more explicit (Elmqvist et al., 2013; Pickett et al., 2011). In turn, this allows some consideration of the effects of aggregation and zonation on related assessments and analyses, i.e. the Modifiable Area Unit Problem (Dark and Bram, 2007; Openshaw, 1984). The urban landscape planning and urban ecology traditions further emphasise spatial dimensions, through for example Forman and Godron’s patch-corridor-

matrix model (Forman & Godron, 1986) and McHarg's "*Design with Nature*" (McHarg, 1969). Among other things "*Design with Nature*" was a guiding basis for the development of layer-based processing in Geographical Information Science (GISc) (de Smith, Longley, & Goodchild, 2013). Unsurprisingly, then, GISc is an important influence on practice in some of these fields and can provide methodological framing as well as influencing what sorts of data are used and why. What sorts of land unit representations are used in Africa, how and why they are generated, what influence they have on findings and what assumptions do they contain?

Evidence suggests that GI relevant typologies can be constructed and used to delineate appropriate land units for analysis (Lindley et al., 2015). However, the complex and heterogeneous nature of African development (Lupala, 2002; Mosha & Mosha, 2012) mean that many zones are in practice 'mixed', especially when applied to intermediate 'neighbourhood' scale geographies across large cities. For some of the five African cities analysed in (Lindley et al., 2015), characterisation using Urban Morphology Types resulted in some very large zones and difficulties in distinguishing between urban and rural. In addition, there is the issue of availability of appropriate, contemporary data at sufficiently high resolution and lack of access to appropriate resources and capacities locally to undertake data analysis in the frequencies required to generate updates to match the rapid state of flux in many African urban areas, particularly where urban sprawl results in large increments in the physical sizes of cities (Seto, Guneralp, & Hutyrá, 2012).

Understandings about urban ecosystem services are therefore equally sensitive to spatial scale. Since we are ultimately considering systems, time is also important. The benefits of urban GI and ecosystem services are time sensitive and they also evolve over time. Therefore a refined understanding of temporal dimensions is needed in order to consider the dynamics of inter-relationships within and between social and ecological systems (Raffaelli & White, 2013).

Despite this, a surprising 82% of ecosystem services frameworks appear not to consider time (Ford et al., 2015), with only 5% having refined conceptualisations. The importance of the temporal dimensions of studies has been recognised in many of the reviews considered here. That importance is further heightened in the case of African cities because of the very high rates and complex patterns of change in urban populations and the spaces they use and hence demands for land, services and infrastructure. These high rates mean the situation can change very rapidly. Frameworks where time is handled in a refined way may therefore be particularly helpful for the African urban context.

Models are an obvious way of operationalising the temporal dimensions of frameworks. They help to move assessments away from ‘mere’ empirical foundations and can also challenge linear thinking and outcomes based only on prior experience (Pickett et al., 2011). Models allow the exploratory ‘what if’ and idealised ‘if only’ scenarios to be examined and provide a foothold into understanding possible outcomes from a range of possible future trajectories. However, since models of land-use change are still limited in terms of feedback between social and ecological elements, this does restrict what is possible in practice (Elmqvist et al., 2013). Currently, there is little opportunity to fully explore inter-related spatial and temporal dynamics and social-ecological processes operating on different scales. Even if there were, complex spatial and temporal framing becomes highly resource and data intensive and therefore a challenge even in the context of relatively well researched cities (Gómez-Baggethun et al., 2013; Maruani & Amit-Cohen, 2007). Nonetheless, a consideration of what sorts of time frames underpin studies and the assumptions that this brings into knowledge bases does need to be made. Decisions about the relative importance of space and time may be influenced by disciplinary outlook which further underlines the need for ambitious inter-disciplinary thinking in this arena.

Both GI and ecosystem services have been defined within this SI volume (du Toit et al., 2018) but the discussion is summarised and extended here as a basis for further analysis. GI can be defined as “an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations” (Benedict & McMahon, 2002). The conceptualisation of GI is strongly linked to planning traditions and a variety of meanings and approaches to its development have emerged on different spatial scales, from national and transnational ecological networks, to regional, urban green space networks and sustainable urban drainage systems at site scale (e.g. Laforteza, Davies, Konijnendijk, & Sanesi, 2013; Pauleit et al., 2017; Rouse & Bunster-Ossa, 2013). The concept is often informed by landscape ecological thinking, e.g. the patch-matrix-corridor model (Forman & Godron, 1986) whereby a holistic consideration of urban landscapes is advocated that includes all open spaces regardless of their origin, use and property.

In an urban context, the role of GI as a strategic planning approach has been emphasised based on principles of connectivity, multi-functionality, integration of grey and green elements and that it is planned in a socially inclusive way (Hansen et al., 2016). Such broad principles require further definition for their application in planning. In this context, ecosystem services have been proposed as a suitable concept to operationalise multi-functionality (Hansen and Pauleit, 2014), thus establishing a meaningful link between these two concepts.

Ecosystem services can be defined as “the benefits human populations derive, directly or indirectly, from ecosystem functions” (Costanza et al., 1997, p. 253). Later papers have expanded this concept to differentiate between functions, services and benefits (de Groot, Alkemade, Braat, Hein, & Willemen, 2010; Haines-Young & Potschin, 2010). Although the ‘urban biome’ was recognised in some of the original work on ecosystem services (e.g. Costanza et al., 1997), it was

only fully developed in the context of urban areas later, e.g. Stockholm (Bolund & HunHammer, 1999). Such assessments demonstrated that urban ecosystems are associated with a range of benefits for human health and wellbeing (Cilliers et al., 2013; Pickett et al., 2001; 2011; Wangai, Burkhard, & Müller, 2016).

More recently, several authors have argued for a more balanced view on the environment and human wellbeing nexus through the inclusion of ecosystem ‘disservices’ (Shackleton et al., 2016; von Döhren & Haase, 2015). They contend that the strident narrative around ecosystem services providing only benefits to humans is one-sided and potentially misleading. A more balanced view would consider ecosystem contributions simultaneously. Consequently, mapping sources, flows and impacts on human wellbeing could be done in an integrated manner with planning and management targeted at optimising benefits and mitigating negative contributions. It also recognises that the same benefit flow might be perceived positively by some, but negatively by others, further emphasising the need to consider disservices alongside ecosystem services (Saunders & Luck, 2016). Although this need has been recognised more widely, e.g. Pascual et al., (2017), much of the discourse around ecosystem disservices has been in the context of urban ecosystems (Gómez-Baggethun & Barton, 2013; Lyytimaki & Sipila, 2009; von Döhren & Haase, 2015). Importantly, the greater amounts of remnant, unmanaged GI in African cities and a lower capacity to pre-empt and manage disservices could mean that ecosystem disservices are more diverse, more prevalent and have greater impacts than they do in the Global North.

This brief characterisation of GI and ecosystem services and disservices provides an overview of key characteristics and lineage. They may have different disciplinary underpinnings but both terms and the frameworks with which they are commonly associated have evolved from considerations which have largely developed in the context of Europe, North America and

Australia (Benedict & McMahon, 2002; Coutts, Tapper, Beringer, Loughnan, & Demuzere, 2012; Mell, 2016; Pauleit, Liu, Ahern, & Kazmierczak, 2011). How can what we know now, help to make ideas more sensitive to the requirements of application in other contexts, as in Africa, where urbanisation takes many different forms and there are many complexities which can be overlooked (McHale, Bunn, Pickett, & Twine, 2013; Myers, 2014)? This includes the somewhat ambiguous nature of urbanisation processes and outcomes which often defy normative models of urban-rural classification and scales of operation enshrined in planning systems (Simone, 2011). It is also unclear how far informality is part of a process of transition or a fundamentally different system of settlement, community and economy which may ultimately prove resilient to change (Hanlon et al., 2017). For this reason, another identified research gap, that of governance (Elmqvist et al., 2013) is pertinent here and links to the need to understand better what sorts of opportunities might come out of informality and the opportunity for local action and change (Anderson et al., 2013).

Some of the other research gaps previously identified are also relevant to Part 2 of this paper. They include (after Anderson et al., 2013; Elmqvist et al., 2013; Jackson & Ormsby, 2017):

- Supply-demand gap – how the need for ecosystem services compares with the provision of services, and their inter-relationships, e.g. in terms of ‘bundles’ of services. Bundles of this type might use thresholds, such as around ‘adequate resources’, ‘benign’ environments and ‘socio-cultural fulfilment’ (Wallace, 2007 in Häyhä & Franzese, 2014). There is also a need to consider associated social-ecological feedbacks, which itself requires inter-disciplinary perspectives (James et al., 2009) as well as synergies and trade-offs and how they can be systematically addressed, e.g. via the planning process.

- Valuation and valuation related gaps – the lack of valuation techniques for some ecosystem services, sometimes also hampered by the lack of evidence of some service types, such as cultural services. They also do not consider valuation from the specific perspective of multi-dimensional poverty in the African context (UNDP, 2014) or the implication of applying valuation forms in contexts where there are weak governance systems and high rates of inequality and corruption.
- Thematic gap – Whilst it is generally recognised that cultural services are under-researched globally, Africa is one of the parts of the world where urban sacred sites have particular significance and diversity (de Lacy & Shackleton, 2017; Jackson & Ormsby, 2017). Such sites are associated with mainstream religious practices, but also with other belief systems where humans are considered to be an integral part of the natural world. Sites can also be an important component of cultural traditions and support related practices such as the keeping of oral histories (Jackson & Ormsby, 2017).
- Geographical gap – Africa is consistently identified as under-researched (e.g. Haase et al., 2014; Wangai et al., 2016). Within Africa studies from South Africa make up the largest proportion of available evidence (Cilliers et al., 2013; du Toit et al., 2018). Given some of the historical drivers to urban form and function in South Africa, not all of its social-ecological systems will translate to other African urban areas.

4. Part 2: Perspectives on urban GI and urban ecosystem services in sub-Saharan cities – concluding on contributions from this Special Issue

4.1 What does this SI further reveal about GI and urban ecosystem services in African cities?

The review which opens this SI reaffirms the serious paucity of studies on urban GI and associated ecosystem services in Africa (du Toit et al., 2018). Of those that do exist, there are still clear biases geographically and thematically. Geographically, no international peer reviewed articles were found for 60% of African countries with some urban regions and forms being particularly poorly represented (du Toit et al., 2018). There is little evidence for small and medium sized cities, despite evidence that this is where most of the urban growth and emerging urban poverty in Africa is happening (Anderson et al., 2013). Thematically, most of the existing evidence is centred on provisioning and regulating services with fewer examples tackling cultural services, bundles and trade-offs (du Toit et al., 2018). Similarly, some urban GI elements are better represented than others, with a considerable emphasis on urban agriculture in much existing literature. The papers in this SI start to address some of these identified gaps. Furthermore, they add further depth to knowledge for a subset of particular areas which are relatively well researched.

The observation that some services are relatively well represented in the literature is only part of the picture since their actual use by urban populations is still not that well understood (Shackleton et al., 2017). Roy et al. (2018) consider the range of services used by low income dwellers in hazard prone communities in Dar es Salaam, Tanzania. They demonstrate the strong dependencies of local communities on regulating and provisioning services, including for livelihoods and resilience. They also show the importance of diversity in urban GI, with 19 different elements identified by local communities as important for quality of life. This importance still needs to be better recognised since communities report reductions in both the

quantity and quality of their local green and blue structures and associated ecosystems. The severe pressure on quality is demonstrated by a reduction in the benefits which can be derived from the same physical spaces (e.g. as a result of reduced fish stocks and seaweed species used for bait, illegal fishing and logging, soil and water contamination and crop failures). Similar situations are likely to be occurring in other cities and local experiences need to be understood alongside evidence of city-wide losses (Lindley et al., 2015). Losses are happening now and are projected to continue. For example in Addis Ababa, Ethiopia, a Business As Usual (BAU) development scenario is estimated to result in the loss of 40% and 42% of the city's land area under field crops and vegetable farms respectively between 2011 and 2025 (Abo-El-Wafa, Yeshitela, & Pauliet, 2017). This is despite evidence that more than half of the produce from these areas is used to support the food requirements of the local urban population, in addition to providing income and employment (Abo-El-Wafa, Yeshitela, & Pauliet, 2017).

Within the provisioning services category alone, uses are highly diverse, going beyond urban agriculture and fuel to harvesting of wild foods and medicines (Shackleton et al., 2017). In South Africa, an average of 64% of township dwellers across nine small and medium sized urban settlements used at least one wild resource, though this varied greatly across the country (Shackleton et al., 2017). Interestingly, there is evidence that wild resources are purchased for use within relatively high income households. In informal urban settlements, provisioning sources contributed around a third of cash and non-cash income. Provisioning ecosystem functions are therefore important as safety nets to meet dietary needs, as sources of informal employment and as a means of income diversification for some of the very poorest of African urban society. However, if excessive demand and other external pressures such as climate change erode the ability of urban ecosystems to support usage levels, this clearly results in an unsustainable situation. It not only damages important ecosystems and livelihoods but also threatens resilience,

climate adaptation and the potential for the development of future adaptation strategies (Roy et al., 2018).

These studies therefore begin to place urban agriculture in the wider context of other ecosystem related benefits and forms of GI which need to be in place to maximise the benefits of urban agriculture and the services it brings (du Toit et al., 2018). Douglas (2016) takes the discussion of multi-functionality further in his perspective piece on flooding in African cities. Drawing on a literature review and evidence generated from 40 years of working on urban flooding issues, he shows how the goals of land and water management systems can be fully compatible with cities maintaining strong urban agriculture sectors. He provides examples of successful flood management schemes performing mutually beneficial regulating and provisioning roles taken from a selection of cases across Africa, covering Accra, Ghana; Kampala, Uganda; Nairobi, Kenya and Bobo-Dioulasso, Burkina Faso. As well as demonstrating values, this bundling of ecosystem services helps to provide the basis for understanding connections and trade-offs. A good example of where trade-off is needed is when considering the impact of different forms of urban development on GI and ecosystem services. Future scenarios for Addis Ababa based on densification (with a doubling of population density) could result in a halving of GI losses compared with BAU (Abo-El-Wafa, Yeshitela, & Pauliet, 2017). However, this must be traded-off against a lower availability of benefits for people in low income settlements and the potential intensification of hazards, like heat-waves. Roy et al.'s (2018), qualitative analysis based on the lived experiences of people in low income settlements in Dar es Salaam identifies the value of fresh air and water to support everyday activities, such as for drying clothes and cooking. Uncontrolled development and densification can have the effect of reducing or even cutting off 'fresh air' flows from sea breezes and impact human thermal comfort and air quality (Lindley et al., 2015).

This SI also sheds more light on elements of GI which are relatively under-researched in Africa. Where available, gardens can be an important means through which multiple functions and bundles of ecosystem services can be delivered and used (Cilliers et al., 2017). As a pervasive element of cities, they can provide an important foundation for urban GI and associated services. Gardens help to connect larger green spaces in urban areas for example for foraging and pollination. However, connectivity is not always wholly beneficial and must be traded-off against the potential for gardens to become a conduit for the spread of invasive species. Given that gardens represent some of the most bio-culturally diverse spaces in cities (Davoren et al., 2015) they can be associated with high levels of introductions of non-indigenous species. Additionally, knowledge about whether species are invasive or not can be limited (Shackleton & Shackleton, 2016). Nevertheless, the multi-functionality of species used in gardens is important, e.g. trees grown for shade, aesthetics, firewood, medicines and fruits with additional benefits such as carbon sequestration and wider urban cooling (Shackleton et al., 2017).

The other core characteristic of gardens is their private ownership and control. Almost three quarters of green cover in the nine small and medium urban areas studied in South Africa by Shackleton et al., (2017) were found to be under private ownership. Proportions are similar to those found in the Global North and elsewhere in the Global South (Gómez-Sal, González-Garcia, Santovenia, & Dávila Prado, 2006; Iverson & Cook, 2000). Gardens are sites of local knowledge of a variety of provisioning and regulating ecosystem functions with strong connections to cultural roles. The types, styles and locations of planting show considerable heterogeneity but also similarities, e.g. between traditional ‘homegardens’ in more rural settings and their counterparts in more urban settings (Cilliers et al., 2017; Davoren et al., 2015). Gardens are shown to provide opportunities for innovation, rapid adaptation and sites for promoting learning around multi-functional ecosystem services and conservation practices. However,

cultural changes operating over generational time scales are leading to a gradual erosion of the necessary indigenous knowledge of the benefits of traditional African garden forms to support future initiatives (Cilliers et al., 2017). This and other challenges to optimise ecosystem service provision in gardens could be addressed by the involvement of various stakeholders, forming a community of practice which could improve social learning as well as having other benefits (Cilliers et al., 2017). If unchecked, the further loss of knowledge provides an additional barrier to sustainable delivery of ecosystem services in Africa to the ones identified in du Toit et al., (2018). The papers in this SI already provide further knowledge to help address the challenges identified in du Toit et al., (2018), but there is still some way to go (Table 1).

Du Toit et al (2018) also touch upon temporal framings highlighting the legacy issues around open lands and the influence of past uses. Unlike in some parts of the world, residents of Africa's smaller urban areas seem to retain an important connection to provisioning ecosystem functions with no reduction in their use with increasing residence time (Shackleton et al., 2017; Schlesinger, Drescher, & Shackleton, 2015). This demonstrates the importance of GI-related heritage as well as thinking about time in terms of rapid contemporary change. It also underscores that valuation methods which seek simply to monetarize 'current' value without adequate consideration of legacy and future potential, are problematic (Knights et al., 2013). Such methods are likely to under-value the true societal worth of urban GI, either accelerating its decline or leading to inferior replacements, i.e. in terms of ecological, cultural, social and environmental functionality.

Despite the importance of private spaces, public GI is still very important for cultural roles, even in smaller cities relatively close to rural areas. Across South Africa there is general dissatisfaction with the availability of public GI for recreation and dissatisfaction increases with increasing

poverty. Almost two-thirds of householders in low income 'RDP' housing estates are dissatisfied compared with around half in more affluent areas. Ironically, though, it is the people in more affluent areas who are more likely to lobby for increases in GI despite higher levels of satisfaction and more public GI to begin with (Shackleton et al., 2017).

Public influence over institutions is one means through which issues around GI might be addressed. However, there can be very different levels of state intervention, priorities and levels of planning across Africa (Herslund et al., 2017). Differences have a bearing on how development occurs and also how far and in what ways GI is considered. The extent of involvement of the state and trust in authority - something that tends to be low in the case of South Africa (Shackleton et al., 2017) - will also influence the likelihood of public engagement. In Addis Ababa a traditional top-down approach to planning has been directed into formal housing developments with more than 8000 condominium blocks established in the last ten years (Herslund et al., 2017). There is a growing, but still relatively nascent, recognition of the value of a GI approach. GI features in plans championed by an academic 'green team' co-opted into the plan development process, but there is still work to do to cascade knowledge more fully and coherently through the system and evolve beyond traditional 'beautification' objectives. In Dar es Salaam, it is suggested that there are critical problems with the entire plan-based system due to delays, data and fragmentation (Herslund et al., 2017). The prospect of bringing a GI focus into this arena seems to be very doubtful given the pervasive problems and conflicting priorities. In Addis Ababa authorities are assisted through the land ownership system whereas in Dar es Salaam a mix of private drivers makes for a highly fluid and piecemeal system with many actors involved. In both cities, local communities are not part of the existing regime. Herslund et al. (2017) propose mechanisms to help promote and harness local innovations and experimentations within the prevailing GI and wider planning regimes. Community measures are also frequently

cited in this SI as the key to improving GI-related activity in African cities. Four examples of methods to achieve better community engagement are highlighted here. One is the better involvement of local community organisations in low income settlements (Roy et al., 2018). A second is the wider adoption of special initiatives like health clinic gardens which attract support from a variety of stakeholders leading to co-production of sustainable gardening knowledge and social learning (Cilliers et al., 2017). A third is through influencing the owners of private gardens (Shackleton et al., 2017). The final one is to ‘empower urbanites’ through payments in wealthier neighbourhoods or time contributions in less wealthy areas (willingness-to-work) (Shackleton et al., 2017; du Toit et al., 2018). Of course, the latter suggestion would need careful consideration from the perspective of ethics and social justice.

Community involvement seems particularly important given that a range of GI types are valued by urban residents (from areas with indigenous vegetation through to more managed environments (Shackleton et al., 2017)). Yet Herslund et al. (2017) alert us to the fact that in the regimes they investigated, the interpretation of GI is very narrow. Despite the importance of urban agriculture, only vegetable farms (not field crops) are included in GI planning in Addis Ababa and neither agricultural type is considered in Dar es Salaam. In Addis Ababa urban agricultural land is prime development land for housing condominiums and industrial development. In Dar es Salaam, the lack of recognition of urban agriculture means that it takes place on amenity land as a temporary use, e.g. by road sides. In both cities, consideration of scale and connectivity, so important to the definition of the GI term, is weakly developed. In Dar es Salaam there is considerable potential for local innovation due to existing social norms and rules. Communities are helping to govern the protection of some communal green space areas, even where others are not afforded the same protection and are either used for waste disposal and/or sold off to new arrivals, such as the more peripheral ‘back of the areas’ green spaces, like those

along riverine corridors (Herslund et al., 2017; Roy et al., 2018). Longer established settlements may need to trade-off the benefits of stronger networks and opportunity for community interventions with a greater proportion of households being rented out to people who may be less well invested in the community, or less able to contribute (Douglas, 2016).

4.2 How have related concepts and frameworks been used and might be adapted to provide a better foundation for research and practice in African cities?

The papers in this SI use a variety of different definitions of urban GI and ecosystem services. While all hold to the key GI principles of connectivity and multi-functionality it is notable that some, e.g. Shackleton et al., (2017), also discuss differences in application – e.g. from planning perspectives to social-ecological systems and resilience. Furthermore, social, bottom-up processes tend to be emphasised more than government top-down processes.

The concept of social-ecological systems is given considerable prominence in many papers due to its emphasis on a coupled consideration of human-environment interactions. This seems particularly appropriate where multi-functionality is high and there are strong links between people and their local environments, as in the case of African cities. The inter-dependency of communities is also highlighted by Douglas (2016). He emphasises the conflicts and trade-offs to be negotiated in the development of successful multi-functional flood management schemes and the human processes which need to be considered. For example, in some flood plain settlements there is a well-established cyclical process of population movement in response to flooding events, echoing the idea of migration as an adaptation practice (Roy et al., 2018). Although floods lead to crop losses and necessitate relocation, such temporary disadvantages are not considered great enough to outweigh the benefits that flood plain locations provide at other times. One solution is to work with this process. However, in doing so there is also a need to consider

knock-on effects on hydrological processes operating from household to catchment scales and the impact that they may have on the frequency and severity of flood events experienced (Douglas, 2016).

The work in this SI shows that the balance and relative importance of functions are different in different African urban contexts. Studies in Africa also tend to emphasise a different set of core elements to those commonly seen in the international literature (Ahern, 2007; Demuzere et al., 2014; Hansen & Pauleit, 2014). For example, Cilliers et al., (2017) and Shackleton et al., (2017) both emphasise the importance of direct medicinal roles as well as the food and fuel elements of provisioning functions. These functions are in addition to indirect benefits for health and wellbeing, such as the promotion of social interactions and the expression of identity and sense of place.

All of the papers emphasise how benefits and systems are related to additional framings and concepts. These include risk (hazard, vulnerability and exposure), adaptation and resilience, social justice, valuation, governance and management, such as integrated water management. Connections are suggestive of the wide range of agendas relevant to urban GI, associated ecosystem services and their management. They point to the variety of benefits and also potential advocates in terms of increasing institutional awareness and identifying synergies.

The other reference point is urbanisation and by extension the nature of GI components within African urban areas. Shackleton et al., (2017) refer to urbanisation in Africa as multi-dimensional, with underlying heterogeneity and complex processes also highlighted (Douglas, 2016). In Dar es Salaam, the high level of urban sprawl and agricultural land conversion (Printz et al., 2015) is also reflected in the patterns of urban air temperatures (Lindley et al., 2015) with a less distinct break between urban/rural micro-climates compared to theory developed from classic

studies in the Global North (Oke, 1982). These observations have implications for the representation of related social-ecological systems. Spatial units for social-ecological systems are discussed in Roy et al. (2018). Roy et al. (2018) prefer the use of an urban ecosystem services framing over GI. This is due to the provenance of GI from the planning discipline and the implications that this brings for understanding the nature and evolution of green structures within informal settlements. However, they also go on to call for the development of creative planning and a local approach built on multi-functionality. In principle, this is not too far from the sort of re-imagining of GI for Africa, set out in Herslund et al., (2017). It is also in keeping with other recent calls for better consideration of the intended audience(s) and purpose(s) of GI interventions (e.g. McPhearson et al., 2016).

Herslund et al. (2017) use transition theory to analyse existing structures and systems by considering GI functions around water management. They use a definition of GI which emphasises connected ecosystem services and see this as a key principle for understanding how a transition might be made from a situation where spaces are less valued to one where they are appropriately valued as multi-functional parts of the urban system. They suggest that this may be a persuasive way to make the case for how GI can simultaneously help urban residents to tackle the raft of pressing issues they face as well as assist with the process of building wider resilience. For example GI benefits could be seen firstly through the lens of access to fresh water (given that the improved access to, and reliability of, water supplies are an essential basic infrastructural need). By extension, GI benefits can also be recast as some of the other solutions to multi-dimensional poverty (e.g. as a route to strengthened and diversified livelihoods). This may become especially important in some African contexts, including: where residents, local communities and wider city authorities are working with outmoded or piecemeal information; where GI is difficult to promote due to traditional associations with beautification; and where

there is a wider sentiment in government and other bodies that the requirements for urban GI are less critical compared to those of other demands faced.

Based on the examples in this SI, research into GI and urban ecosystem services in Africa employs a range of concepts and frameworks. Their selection depends on the scope and nature of research goals as well as the disciplinary traditions and epistemological foundations of researchers designing and conducting the work. There is still considerable scope to develop frameworks for further research, not least as there is some indication that even the urban ecosystem services concept itself is still not widely used in Africa (Cilliers et al., 2013; 2017). All of the papers provide observations on the specific characteristics of processes and contexts in each case, with clear links to underpinning theory. Some authors have reflected on the suitability of frameworks (e.g. Roy et al., 2018), though this is perhaps not fully resolved.

Developing new frameworks is also beyond the scope of this conclusion. However, in rethinking GI and urban ecosystem services from the perspective of the Africa-based research in this SI, a number of suggestions can be made. For developing and applying concepts and frameworks in research and practice, there is a need to:

- Pay particular attention to the handling of time and space, scale and their connectivity, particularly to understand rapid and varied rates of change, associated processes and appropriate metrics in the context of land units which are frequently rather indistinct.
- Make framings sufficiently adaptable and flexible to incorporate urban heterogeneity, for example in terms of urban form, development patterns and social-ecological systems, including in communities and governance. These may be manifested in specific land management, tenure/ownership practices and traditions or in the closeness with which social and ecological processes are connected in different community, social and spatial contexts. A

failure to recognise this heterogeneity in evidence produced for policy and practice may lead to environmental injustices for vulnerable, disempowered groups.

- Demonstrate how the relative importance and value of GI and its ecosystem services may be distinct in urban Africa, for example in terms of the importance of diverse forms of urban agriculture, the role of medicinal functions, and the significance of spiritual and sacred sites representing human relationships with nature. This has implications for what is considered and how it is considered, e.g. in terms of measurement and valuation.
- Further recognise how differences in ecosystem disservices are experienced and the nature and importance of disservices in African contexts, how benefits come together, trade-off from one another and can tip from services to disservices, e.g. when the quality of a particular benefit becomes sufficiently degraded.
- Consider connecting urban GI benefits and drawbacks to wider factors explaining multi-dimensional poverty. This could also consider how far quality of life is impacted through pathways affected by GI and ecosystem services such as through livelihoods and safety nets as well as health and wellbeing.
- Further develop valuation methods to capture the absolute and relative importance of ecosystem-related functions as life-line infrastructure in different areas (Roy et al., 2018; Douglas, 2016; Lindley et al., 2013), legacies in terms of biodiversity, social and cultural heritage (Cilliers et al., 2017; du Toit et al., 2018) and sites for learning and potential innovation (Cilliers et al., 2017; Herslund et al., 2017). Concerns about the limitations of monetary valuation in a European context (Knights et al., 2013) seem all the more pertinent for Africa given more extreme income and investment inequalities as well as due to weak governance, corruption, a lack of controls and rapid change. Inclusive participatory methods and approaches may be particularly useful, especially where communities need to become the

major agents of change and custodians of their local environment within models like the one proposed by Herslund et al., (2017).

- Seek to represent both bottom-up and top-down processes and develop methods and approaches which explicitly handle community bottom-up innovations and initiatives and help to build capacities (du Toit et al., 2018; Herslund et al., 2017; Table 1).
- Further recognise the specific needs (including research needs) around institutional capacity building at different scales of governance and how this relates to developing mechanisms for the implementation of GI at all levels (Herslund et al., 2017; Sitas, Prozesky, Esler, & Reyers, 2014). There is a particular need to widen and deepen understanding of the social dimensions of social-ecological systems to help inform action.
- Consider non-linear development trajectories and support a re-imagining of urban visions which challenge world views in which GI (e.g. urban agriculture) loss is seen as a positive sign of transition to a more mature urban form, not least given the renaissance of urban agriculture in the Global North (Taylor & Lovell, 2014).
- Seek ways to respond to the full range of opportunities in urban Africa, i.e. from preserving remnant patches of indigenous ecosystem functionality, to establishing/re-establishing multi-functional GI with different scales and forms of development projects.

4.3 How far does this SI help to address gaps and what future research agendas emerge?

This SI has provided further empirical and theoretical evidence of urban GI and associated ecosystem services in Africa and considers means for their sustainable delivery (du Toit et al., 2018). However, there remains a dire shortage of research in and on Africa on these themes in the international academic literature. To some extent this SI has further compounded the bias towards

South Africa, but the research published here has brought new thematic insights in terms of private GI spaces and also improved the evidence base for smaller cities, towns and settlements (Cilliers et al., 2017; Shackleton et al., 2017). The SI has also pulled together evidence from other cities too, notably Addis Ababa and Dar es Salaam (Abo-El-Wafa, Yeshitela, & Pauliet, 2017; Herslund et al., 2017) but also elsewhere in Africa using a range of knowledge bases (Douglas, 2016).

In this paper, we also provide the first dedicated analysis of how concepts and frameworks are being applied across a body of research centred on GI and ecosystem services in African urban areas and suggest reference points for future studies. This is important as African variants on ideas developed largely from the perspective of the Global North are yet to emerge. For example do the specific characteristics of African towns, cities and settlements merit a rethinking of terms like urban GI to recognise ‘community urban GI’ as a distinct marriage of bottom-up community planning with local values of the benefits of multi-functionality and connectivity? To what extent does the concept of GI have a limited role in unplanned contexts, or can ‘creative planning’ (Roy et al., 2018) be successfully married with a wider appreciation of GI’s core tenets of multi-functionality and ecological connectivity as part of an improved understanding of African social-ecological systems? Should urban ecosystem services be a concept more widely promoted in Africa, or rather a new value-based approach developed to help with responding to the challenges of sustainable delivery of benefits? We have considered some of the foundations on which future framings might be develop to address these questions better.

There is still a need for more empirical evidence to help inform decision-making and the development of theory on the social and ecological dimensions of urban GI and ecosystem services in Africa. There is little research on social elements, particularly going beyond

recreational roles to consider how strong cultural and spiritual affiliations with nature can be recognised and protected. There is also limited knowledge about how processes operate spatially and socially. Sustainable solutions will need to marry social aspirations and goals for urban life in Africa in the 21st Century with the conservation of high native biodiversity and conflicting ecosystem uses, e.g. the high prevalence of free-roaming urban livestock. Sustainable solutions will inevitably require equal consideration of perspectives and requirements from people across a spectrum of urban neighbourhoods. It may also require the development of novel methods for engagement so as to reach people in communities with low citizen literacy, low local mobility and high transience as well as people living in more established communities with higher levels of education and wealth.

Inevitably there is still much to do and a need for foundational as well as applied research. For example, one research direction could be the representation of heterogeneous urban zones around fuzzy memberships rather than crisply delineated zones or the development of other methods to represent the different urban-rural and social gradients seen in Africa, e.g. building on analyses like Zhou et al., 2017. To assist with this task, what sorts of typologies of African urban social-ecological systems can be developed which take account of rates of change, land tenure, community cohesion, transience with the physical structures of green and grey areas? Advancing a multi-level perspective to enhance integration of GI into urban development means that there is a need for the integration of more research on GI governance (Herslund et al., 2016; 2017). On the one hand, such research should increase capacities for strategic decision-making, e.g. in terms of GI networks that influence overall urban development (e.g. Printz et al., 2015; Fohlmeister, Pauleit, Touré, & Yeshitela, 2015) but on the other hand also retain the capability to support local activities so that multiple roles are supported.

Transdisciplinary approaches are required linking science with practice over a longer-term perspective, i.e. considerably beyond the usual three year funding regimes for research projects and which can make a difference to delivery of the UN Sustainable Development Goals. The idea of establishing “urban learning labs” as arenas for collaborative working and learning, currently popular in international research agendas (Childers et al., 2015), may prove an effective tool for this purpose but they will need to be adapted to the specific requirements of African cities. Here, relatively well researched cities, such as Addis Ababa, Dar es Salaam and Durban could act as lighthouses for wider exchange and the basis for a deeper synthesis of evidence. The interdisciplinary foundations and wealth of perspectives represented in research in some of these cities can provide both a benchmark and a springboard for work elsewhere in Africa. Investment into capacity-building for major stakeholders must be a strong component of such efforts so that outcomes will be continued after the lifetime of particular projects. This may help overcome some of the problems of weak management capacity and a limited knowledge of, and visions for, GI and the ways that local citizens can contribute. A wide range of stakeholders need to be mobilised and engaged for this purpose, including through the development of ways in which plural cultural views can be heard, integrated and conserved within mainstream practice. Only through ambitious, transdisciplinary research endeavours coupled with similarly ambitious funding and support models can urban GI opportunities be realised for a truly sustainable, socially just and uniquely African urban future.

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1118 Table 1: Contributions from this SI to understanding and responding to challenges around the
 1119 sustainable delivery of urban ecosystem services in Africa.

1120

Challenge (du Toit et al., 2018)	Explanation of challenge (after du Toit et al., 2018)	Selected insights from the rest of this SI and some of the remaining challenges
Socio-cultural values, traditions and perceptions	Lack of knowledge of socio-cultural values. Challenges include a lack of relevant local valuation; monetary valuation evidence being at odds with non-monetary trade systems.	Roy et al.'s (2018) identification of multi-functionality supports the consideration of the range of values in low income settlements. Multiple benefits are also considered in Cilliers et al., (2017) and Shackleton, et al., (2017). However, the evidence base is still relatively poor.
Lack of capacity and expertise	A strong chain of dependencies affecting capacity from financial to technological followed by institutional and infrastructure-related. Poor awareness levels & the need for education.	Herslund et al. (2017) propose novel governance frameworks with Cilliers et al., (2017) identifying the role for health clinic gardens and Roy et al. (2018) demonstrating the role of community based and other organisations.
Governance, urban	Lack of coordination and	Douglas (2016) identifies the lack of

planning and social inequality	cooperation at different scales among stakeholder groups and boundaries; lack of ownership and tenure information and therefore the identification of rights.	holistic planning as a further challenge. A range of scales are covered in the SI. Herslund et al., (2017) provide possible structures and processes for improving governance.
Lack of data and/or case studies	Lack of evidence to showcase benefits both for valuation and also awareness-raising. Lack of baseline data to support activities.	Multiple new perspectives are given on some of the same cities based on international research projects. However, the strengths of a rich evidence base is countered by the difficulties using evidence generated using different terms, methods and definitions. Despite other major initiatives for compiling evidence and emerging evidence for smaller cities (Shackleton, et al., 2017), there is still a limited base in Africa especially beyond South and East Africa.
Ecosystem disservices	Urban GI is related to some disservices – whether perceived or experienced. A range of risks are identified	Disservices may be a result of the degradation of green and blue spaces and their ecosystems, sometimes as a result of inappropriate use (Roy et al.,

	(fire, drowning, criminal activity, contamination).	2018).
Spatial trade-offs and conflicts	Examples given include the trade-off between food production and flood reduction.	Douglas (2016) demonstrates the spatial social-ecological processes associated with urban agriculture and flood management. The example of different urban development scenarios is also explored including possible consequences (Abo-El-Wafa, Yeshitela, & Pauliet, 2017; Roy et al., 2018)
Climate Change	Lack of local data hampers mitigation and adaptation responses.	Roy et al. (2018) discusses the role of urban ecosystem services for resilience and climate adaptation. However, there is still only a limited evidence base exploring how urban ecosystem services will be affected by climate change.