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A FRAMEWORK FOR

A GREEN INFRASTRUCTURE PLANNING APPROACH

IN THE GAUTENG CITY-REGION

SEPTEMBER 2016

Written by
Christina Culwick and Kerry Bobbins, with contributions from Anton Cartwright and Gregg Oelofse, Myles Mander, and Stuart Dunsmore

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A framework for a green infrastructure planning approach in the Gauteng City-Region

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Photograph by Gareth Pon

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GLOSSARY OF KEY TERMS

ECOLOGICAL INFRASTRUCTURE	The ecological or nature-based complement to grey (or built-up) infrastructure. This can include catchments, rivers, wetlands and intact natural areas.
ECOSYSTEMS	Biological communities and their non-biological (physical) environment that together sustain life.
ECOSYSTEM SERVICES	The benefits provided by ecosystems (ecological systems or ecological assets) to society.
GREEN ASSETS	All natural and planted ecological features of a landscape. This can include trees, wetlands, parks, green open spaces and original grassland and woodlands etc.
GREEN INFRASTRUCTURE	The interconnected set of natural and constructed ecological systems, green spaces and other landscape features. It includes planted and indigenous trees, wetlands, parks, green open spaces and original grassland and woodlands, as well as possible building and street level design interventions that incorporate vegetation. Together these assets form an infrastructure network providing services and strategic functions in the same way as traditional grey infrastructure.
GREY INFRASTRUCTURE	The set of man-made or engineered systems and other features that involve the use of traditional technology and building materials such as concrete, bricks and impermeable surfaces.
GREY-GREEN DESIGN SOLUTIONS	Combined grey-green infrastructure solutions that incorporate both ecological and traditional infrastructure features, such as permeable pavements, bioswales, bio-retention structures and natural buffer strips.
RESILIENCE	The capacity of a system (urban, rural or other) to absorb disturbances or shocks and reorganise to retain the same functions, structure and feedbacks.
SHOVEL-READY PROJECTS	This term is a metaphor for projects that have leadership support, a detailed budget, and can be implemented as soon as budget is secured.
URBAN HEAT ISLAND EFFECT	The warmth generated by urban areas in comparison to the surrounding environment due to heat absorption in built-up areas.

Part A

Laying the foundation for a green infrastructure approach

1. Introduction

The Gauteng City-Region (GCR), like many urban areas around the world, is growing fairly rapidly in terms of population, economy and spatial extent. This growth needs to be accommodated through the provision and maintenance of urban infrastructure that meets the need for services by both society and the economy. However, this process has traditionally led to urban environmental challenges associated with significant changes in land cover – from natural landscapes to built-up areas – at the expense of biodiversity and the environment (Schewenius et al., 2014). This in turn has a negative impact on the delivery of ecosystem services (ES) provided by various ecological assets and environmental systems.

ES refer to the provision of services by nature and can include *inter alia* water supply, air purification, flood attenuation, pollination and natural recycling of waste (European Commission, 2009). Ecosystems and the services that they provide are critical for supporting and sustaining habitable spaces, which in turn create resilient and liveable[1] cities.

Green infrastructure (GI) has emerged as an alternative approach (or partner) to traditional infrastructure provision that harnesses the functioning and services provided by ecosystems. GI is defined as an interconnected set of naturally occurring or constructed ('man-made') ecological assets that exist at a specific site or street-level, or across wider landscapes. It includes networks of planted and indigenous trees, wetlands, parks, open spaces, original grassland and woodlands, as well as building and street-level urban design interventions (Schäffler et al., 2013). Green assets can contribute to meeting urban needs through the provision of services such as temperature control (reducing the extent of temperature fluctuations which in turn brings down energy consumption), purification of wastewater, stormwater control and nutrient cycling (European Commission, 2009).

A GI planning approach aims to help meet the growing demand for infrastructure and services by retaining and expanding GI networks to ensure the proper functioning of natural ecological systems in urban areas. Evidence from international research suggests that the approach can be used as an alternative or used in tandem with traditional infrastructure options, providing multiple benefits for government and society. This is especially true where multiple stressors intersect and compound challenges related to urban infrastructure provision. In particular, there is growing pressure to meet short and long-term infrastructure and service needs in a sustainable way, within a context where rapid urban growth and the potential impacts of climate change are increasing, and where city governments face growing mandates with limited budgets and stretched technical capacity, as is the case in the GCR (Gauteng Provincial Government (GPG), 2009).

However, despite the uptake of the concept of GI in urban development programmes around the world, GI has as yet found limited purchase in

1. The liveability of cities depends on a range of factors that together contribute to the quality of life supported by the physical urban form. Some of the factors that relate specifically to green infrastructure include amongst others: environmental sustainability, and healthy urban ecosystems that facilitate good air quality, well-functioning nutrient cycles and quality green spaces.

> **"A GI planning approach aims to help meet the growing demand for infrastructure and services by retaining and expanding GI networks to ensure the proper functioning of natural ecological systems in urban areas."**

Photograph by Amanda van der Walt

spatial and infrastructure planning practice in the GCR. This Report – an output of the Gauteng City-Region Observatory's (GCRO) on-going Green Assets and Infrastructure (GAI) project – tries to advance the case for greater adoption of GI in provincial and municipal planning in the region.

GCRO's GAI project was initiated in 2011 and aims to inform the development of a GI planning approach in the GCR. Broken up into a set of sub-projects, to be completed over a number of years, the GAI project sees the GCRO working with research partners and stakeholders, principally from provincial and local government, to investigate and promote the concept of GI planning in the GCR. Research undertaken within the project aims to demonstrate (conceptually and practically) how networks of green assets can assist with delivering services, and how these services can be maximised to bring about social and environmental benefits. It furthermore aims to explore how the GI approach has the potential to minimise risks – such as those associated with densification, urban development and climate change – while improving service delivery and creating jobs.

One of the key objectives of the GAI project is to inform the Gauteng Integrated Infrastructure Master Plan (GIIMP) that is currently being developed by the Gauteng Planning Division (GPD), previously known as the Gauteng Planning Commission (GPC). The GIIMP will serve as an inter-governmental and inter-sectorial planning tool that provides a framework for integrated infrastructure planning for energy, water, information and communications, social services, human settlements, tourism, green assets, and transport.

The first output of the GAI project, published in July 2013, is the *State of Green Infrastructure in the GCR* report (SoGI) (Schäffler et al., 2013). The report established the principles that underpin GI, outlined the context for GI planning in the GCR, and presented an initial valuation of municipal approaches to urban ecological systems. Creating the foundation for further research, the report presented:

- A detailed analysis of the extent, distribution and accessibility of green assets across Gauteng;
- An assessment of how ES produced by GI might be valued; and
- An interrogation into how green landscapes are socially constructed in the GCR.

In its conclusion, the report highlighted a number of possible directions for further research on GI in the GCR. In summary these were:

- **Prioritising ES.** Using international guidelines for valuing ES does not necessarily assist with prioritising ES in municipal planning, management and finance systems. Research is required to understand how – in what format or capacity – ES valuation can be used to address key challenges in the city-region.
- **Government expenditure.** The uptake of alternative infrastructure approaches requires a detailed understanding of public revenue, expenditure and accounting processes. At present, there are limited incentives to shift toward GI alternatives, and no avenue for the value of ES to guide municipal decision-making and expenditure. Future work should explore and define the requirements and opportunities for including GI in these processes.
- **Integrated data inventories.** The availability of green asset data is limited and the quality of digital spatial data is not consistent across municipalities in Gauteng. Municipalities have different standards for collecting, digitising and housing datasets. This creates challenges for assessing and managing green asset networks that extend across administrative boundaries. There is a need to work towards developing standards and defining a methodology for creating GI datasets that can support the development of a GI planning approach.

The SoGI report conclusions have been used to guide the next phase of the research towards developing a GI planning approach for the GCR, a phase focused on better understanding the opportunities for implementing GI in planning programmes and addressing some of the challenges associated with shifts towards this approach.

Over the period 2014-2015, the GAI project pursued two parallel tracks of work. The first track saw the commissioning of specialist inputs from key South African experts. These experts wrote contributions on the valuation of ecosystem goods and services through financial and non-financial methods, and on the design of engineered grey-green infrastructure solutions.

Photograph by Clive Hassal

The major aim of these expert pieces was to further investigate the barriers to the uptake of GI identified by the SoGI report and to provide specialist insights into what is required for a GI planning approach to be adopted in the GCR.

The second track involved the establishment of a GI CityLab, a platform for knowledge co-production between GCRO, government officials and selected stakeholders. The CityLab constituted a series of strategic engagements with officials from municipalities across Gauteng as well as other invited stakeholders. To deepen understanding of how government can better make use of GI, participants were asked to reflect on the possible contribution of GI within their day-to-day work, and assess the obstacles to GI planning alternatives being adopted more frequently and readily at the local level.

The expert inputs, and reflections from the GI CityLab discussions, are assembled into this Report, which serves as a follow up to the SoGI report and is the second major output of the GAI project.

This Report is divided into three broad sections. Part A focuses on introducing and exploring the theoretical and conceptual underpinnings of a GI approach. It extends the conceptual foundations laid by the SoGI report and establishes the importance of incorporating a GI approach in the GCR.
Part B presents the three pieces written by external experts. They consider how GI and ES can be valued by municipalities, and how grey-green design solutions can be implemented in the GCR. Part C reflects on the stakeholder engagement process that has been undertaken, primarily through the GI CityLab, to deepen understanding of how GI can be embedded in municipal planning and decision-making processes. Based on these research findings, this Report concludes with a framework for GCRO's next phase of work on building a GI planning approach in the GCR.

2. Overview of a green infrastructure approach and its applicability for the Gauteng City-Region

*WRITTEN BY KERRY BOBBINS**

2.1. Introduction

"Humanity is increasingly urban, but continues to depend on Nature for its survival."
Bolund and Hunhammar, 1999: 293

Green infrastructure (GI) is not a new concept. Its origin stems from early landscape planning applications used in the 19th and 20th centuries to promote the development of urban nodes that were interconnected with the surrounding natural landscape. The concept has since become rooted in academic theory and draws on the key academic disciplines of landscape ecology, geography, and planning. Underlying this planning concept are the core principles of multi-functionality, connectivity and scale which support a landscape management approach where urban green networks (and their associated ecosystem services (ES)) can be planned and managed to meet specific infrastructure and service needs. While the GI concept is used extensively to manage the functionality of natural landscapes (or intact ecosystems), its application in the dynamic urban landscape is yet to be understood in its entirety. This is largely due to the gap that remains between theory and practice.

There is a growing body of theoretical literature on the use of GI to inform urban infrastructure and service-based planning in urban areas. This literature is developed to better understand how the concept of GI can be used to inform the development of more efficient, cost-effective and sustainable urban infrastructure. In the United Kingdom (UK), United States of America (USA) and Europe, GI is used as an alternative urban planning approach and way to rethink the value of natural environmental features (or ecosystems) in cities. Here, the GI concept has been used to address a wide array of urban-based functions – such as attenuating floods, reducing the urban heat island effect, saving energy, improving air and water quality, increasing cultural values and supporting food security (Roe and Mell, 2013). Through a number of noteworthy applications in London (UK), New York City (NYC) (USA) and Copenhagen (Denmark) (explored in more detail in Section 2.5), the importance of the GI concept is demonstrated by its ability to alter the way in which urban landscapes are perceived and managed by both city managers and communities.

This chapter presents the theoretical underpinnings of a GI planning approach and lays the necessary foundation from which to guide the development of GI framework in the Gauteng City-Region (GCR), illustrating its value and benefit for society and the environment. To achieve this, the following questions are addressed:

- What is a GI planning approach?
- How has it been applied in cities around the world?
- How can the concept be implemented in the GCR?

This chapter extends the theoretical application of GI to the GCR, where the Gauteng City-Region Observatory (GCRO) believes that it offers opportunities to support meeting the GCR's urban infrastructure and service needs. In particular, the uptake of the GI concept in urban planning can enhance infrastructure functions and service delivery where ecological systems may not be intact, where biodiversity is low, and where a significant amount of development has already taken place. In addition, the concept is likely to hold potential to support meeting urban environmental challenges, while also presenting opportunities for creating decent work, enhancing food security and building sustainable communities (outlined by the Gauteng Planning Division (GPD) as foremost challenges of the GCR).

It should be stressed early in this Report that while much insight can be draw from the review of existing GI applications rooted in other contexts, the scope and use of the concept needs to be moulded to

* Gauteng City-Region Observatory (GCRO)

suit the GCR's specific infrastructure and service based challenges.

2.2. Green infrastructure approach

2.2.1. The GI concept

Early landscape planning applications in the 19th and 20th centuries, such as Olmstead's parkways concept and Howard's garden city movement, laid down the necessary conceptual foundations of a GI planning approach by promoting the idea of environmental connectivity between urban green assets – such as parks and green spaces (Mell, 2008). Over time, the GI planning approach has been adapted to include the principles of landscape ecology, geography, and planning (Ahern, 2007), and this has encouraged the planning and management of green assets to provide strategic services in urban contexts (such as ecological, recreational, cultural, aesthetic and educational) (Mell, 2008).

Since the late 1990s, GI has become a prominent theme in urban planning in the UK, USA and Europe (Mell, 2008). In these contexts, the GI concept has been used to overcome urban challenges associated with climate change and changes in land use (conversion of natural to built-up). These challenges have been overcome through the development of individual GI plans that actively link the core functions of GI to various urban-based challenges (to be presented in more detail in Section 2.5) (URBES, 2013a). The development of GI plans in cities across the world has contributed to an emerging body of international academic and applied research, which in turn has facilitated its uptake in urban areas (Mell, 2008).

What is evident within this growing body of knowledge is the lack of a uniformly recognised definition of GI (Hansen and Pauleit, 2014). Rather than being a limitation of this planning approach, it is considered to be its strength as it allows for the designing of site-specific GI plans that are able to meet a host of infrastructural and ecological needs (Hansen and Pauleit, 2014). In Europe, for example, GI is typically defined as all natural environmental (or ecological) features; whereas in the USA, GI is defined as both environmental features and engineered GI solutions (NYC, 2009; Philadelphia Water Department, 2014). While these definitions of GI both place a general focus on existing natural systems, the inclusion of purposefully designed or constructed engineered GI solutions is a specific feature of GI plans in the USA (NYC, 2009; Philadelphia Water Department, 2014). These subtle nuances are demonstrated in Table 2.1.

2.2.2. Guiding a GI planning approach in urban contexts

The use of the GI concept in urban planning allows for the implementation of flexible or fit-for-purpose infrastructure planning solutions that take into account the local context (Ahern, 2007). This is facilitated by the broad definition of GI and through the involvement of stakeholders in the development of a GI planning approach. The involvement of a variety of stakeholders allows for ES to be effectively managed or enhanced to overcome a variety of urban-based objectives *inter alia* stormwater management, sustainable urban design, sustainable communities, climate change adaptation, liveability, biodiversity and conservation (Fish, 2011; Mell, 2012; URBES, 2013b). To effectively manage and enhance ES, a GI plan is developed and used to guide the uptake of a GI planning approach. The GI plan is therefore a blueprint (or map) of how GI will be used to meet the local requirements, or the need for infrastructure and services.

Each individual GI plan is developed using a stakeholder-based approach that can be run by city officials, research entities or the public. This approach allows for the inclusion of cross-sectoral or

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cross-discipline interactions in the planning domain (Ahern, 2007; Lovell and Taylor, 2013), (see Section 2.4.2 and Chapter 6) and ensures that the final plan addresses the overarching goal of the GI planning approach, and meets the needs of a range of stakeholders (Lovell and Taylor, 2013; Roe and Mell, 2013).

To guide a GI planning approach to meet local service needs, authors such as Benedict and McMahon (2006), Ahern (2007) and Beier et al. (2011) present on a set of guidelines to inform the development of a GI plan. The points listed below indicate a summary of steps outlined by these authors. Box 2.1 presents a general application of these guidelines:

- Identify a common project goal via a group of stakeholders;
- Demarcate a project study area;
- Identify and collect available data and information on features included in the GI plan;
- Interrogate and interpret collected data;
- Create a visual output of features of interest (such as a map or spatial plan);
- Set project priorities according to the overarching map goal; and
- Review the final output using the project stakeholders and select experts.

Box 2.1: Developing a green infrastructure plan in Maryland (USA)

Maryland is a state in the USA where significant habitat fragmentation and land degradation has led to the reduction of critical ES (Maryland Department of Natural Resources, 2003). To overcome this, Maryland developed a GI Assessment to prioritise land for conservation and restoration to slow the rate of habitat fragmentation and to provide environmental services (Weber and Wolf, 2000; Maryland Department of Natural Resources, 2003).

Developers, landowners, citizens, and planners in Maryland stand to gain the most from landscape conservation and restoration as a result of enhanced ES produced by intact and functioning natural landscapes. As such these stakeholders have an interest in improving natural landscapes and they are considered core stakeholders in the formation of the infrastructure plan (Maryland Department of Natural Resources, 2003). The stakeholders assisted with the development of a common project goal – which was to develop a spatial tool to inform landscape management decisions. It was decided that the project study area was defined using the Maryland state boundary (Weber and Wolf, 2000).

All available digital spatial data on natural landscape features were collected (through various stakeholders) and included *inter alia* land cover, wetlands, heritage areas, protected land, soils, watershed, zoning, flood lines, biological surveys, development pressure and roads (Weber and Wolf, 2000). Data were collected, interrogated, and cleaned for use in a Geographic Information System (GIS). Data were then used to map 'hubs' (areas of significant ecological importance such as sensitive species, wetlands of state concern, engendered species, forest, etc.) and 'corridors' (features that link hubs to allow for the movements of plants and animals such as ridges, rivers, forest and valleys, etc.) (Weber and Wolf, 2000; Maryland Department of Natural Resources, 2003; Weber et al., 2006). The hubs and corridors were then produced in the format of a visual output. This allowed for the prioritisation of blocks of land according to the overarching map goal (either to be conserved or restored). Blocks of land cover were selected based their specific ecological value (and environmental services) for conservation (Weber and Wolf, 2000; Maryland Department of Natural Resources, 2003).

Lastly, a group of stakeholders and experts reviewed the output to ensure it met the overall project goal (Maryland Department of Natural Resources, 2003). A set of revisions were then made to refine the overall plan.

2.3. Underlying concepts

Three key concepts guide the development of a GI planning approach, namely multi-functionality, connectivity, and scale. These concepts provide a basis from which to consider how GI can guide infrastructure and service-based planning.

2.3.1. Multi-functionality

GI is unlike traditional infrastructure as it can provide a host of ES, rather than just a single service. The multi-functional nature of GI is of particular interest in urban planning as it allows for many planning agendas to be met simultaneously. To demonstrate the concept of multi-functionality, Bolund and Hunhammar (1999) identify ES provided by urban ecosystems in Stockholm (Sweden) (Table 2.1). In their study, they point out a number of individual urban green assets that are common across urban landscapes around the world (many of which can be found in the GCR). For example, street trees are considered to be a common urban green asset and can provide *inter alia* air filtering, microclimate regulation, noise reduction, and recreational and/or cultural services (Bolund and Hunhammar, 1999). In addition, Bolund and Hunhammar (1999) also recognise that additional indirect services can be provided by urban green assets. An example of this is increased quality of life (Hansen and Pauleit, 2014).

Studies by Tallis et al. (2011) and Nowak et al. (2013) further illustrate some of the multi-functional values of urban ecosystems, in particular those associated with urban trees (or street trees). Tallis et al. (2011)

Photograph by Clive Hassal

Table 2.1: Urban ecosystems identified to generate multi-functional services

SOURCE: Bolund and Hanhammar, 1999

Local and direct services	Urban green assets						
	Street tree	Lawns/ parks	Urban forests	Culti-vated land	Wet-land	Stream	Lakes/ sea
Air filtering	X	X	X	X	X		
Micro-climate regulation	X	X	X	X	X	X	X
Noise reduction	X	X	X	X	X		
Rainwater drainage		X	X	X	X		
Sweage treatment		X	X	X	X		
Recrea-tional/ cultural values	X	X	X	X	X	X	X

present that the urban tree canopy in London can remove up to 2 121 tonnes of PM10 (particulate matter, smaller than 2.5μm in diameter) annually, resulting in air quality improvements of 0.7 – 1.4% (Tallis et al., 2011). Similarly, air quality findings in ten American cities indicate that the existing stock of urban trees remove particulate matter, smaller than 2.5μm in diameter ($PM_{2.5}$), from atmosphere (Nowak et al., 2013). This varied from 4.7 tonnes of $PM_{2.5}$ per annum in Syracuse to 64.5 tonnes per annum in Atlanta (Nowak et al., 2013). In some cases, the average air quality (improvement as an annual percentage) was between 0.05% (San Francisco) and 0.14% (Atlanta) (Nowak et al., 2013).

Using non-monetary scientific-based studies to translate the benefits of ES into relative terms such as the cost of hospital admissions, Tiwary et al. (2009) show that the services provided by urban trees can be measured against traditional urban services such as healthcare. For example, the existing tree cover in London can lead to the avoided costs of two deaths and two hospital admissions per year (Tiwary et al., 2009)[2].

2. These figures were calculated for the wider East London Green Grid. Estimates are based on emissions data retrieved from the London Atmospheric Emissions Inventory, available meteorological data and via tree canopy uptake models to discern the hourly uptake of PM10 over an area of 10 000 ha.

"GI refers to the connected set of green assets (natural or constructed) and other environmental features that together make up the GI network."

2.3.2. Connectivity

GI refers to the connected set of green assets (natural or constructed) and other environmental features that together make up the GI network (Benedict and McMahon, 2002). Connectivity is a key characteristic of robust GI networks as it allows for the provision and regeneration of ES (from natural and constructed green assets) across the landscape. Here connectivity is described as "the relationship between landscape structure and functions" (Ahern, 2007: 270) and is not necessarily a direct physical connection between different GI features; rather it can include where green assets are located in close proximity to each other (Town and Country Planning Association, 2008). The connectivity between green assets can be determined by identifying individual green assets and their functions as part of a broader network of green features at a city, or regional scale (Town and Country Planning Association, 2008).

Changes in urban environments, such as those associated with land use (from natural to built-up), can lead to the fragmentation of GI networks, and this reduces the connectivity between green assets across the landscape (Ahern, 2007). This in turn undermines the services provided by green assets as the functional proximity (or distance) that exists between green features has been reduced or lost (Ahern, 2007).

2.3.3. Scale

The concept of scale (the physical dimension in space) has become synonymous with a GI planning approach (Hein et al., 2006; Ahern, 2007). This is because GI networks generate ES at different spatial scales, and this allows for the provision of services either short-term at the site-level scale (such as utility services like flood abatement), or long-term at a global scale (such as carbon sequestration) (Hein et al., 2006). The spatial scales at which ES services are provided can be hierarchical, which implies that services provided at the site-level can be enhanced or supported at the regional and/or global scale.

Investigating the scale at which GI networks generate ES is essential for determining how the supply of services may benefit or be of interest to stakeholders – landowners, city officials, planners, and engineers (Hein et al., 2006). This logic extends to include the modification or extension of existing GI networks through natural or constructed green assets to improve service provision. For example, site-scale GI options can enhance regional landscape services (e.g. bioswales and rain gardens contribute to regional stormwater management) (The Chicago Metropolitan Agency for Planning (CMAP), 2014).

2.4. Using GI to inform infrastructure planning

2.4.1. Grey-green design solutions

A GI planning approach also includes the use of grey-green design solutions, or purposefully designed infrastructure interventions, integrated with existing natural environmental features. In many cases, grey-green design solutions can allow for the direct replacement of traditional grey infrastructure with a grey-green alternative, or it can be used to complement existing grey infrastructure (EPA, 2014a).

As shown by the Scottish government (UK), street trees, green roofs, permeable pavements, swales, and natural buffer strips can be used as a direct replacement for traditional infrastructure such as road bollards, roofs, concrete stormwater channels and rainwater pipes (see Table 2.2). In greater Berlin, Germany, shifts to the use of grey-green design solutions to reduce the generation of stormwater have been incentivised through a 'stormwater utility fee', which charges landowners for the total area of impervious surface on their parcel of land. The greater the area of impervious surface, the higher the fee charged to the landowner. This has prompted the roll-out of a number of GI storm water attenuation solutions such as green roofs, retention ponds and rainwater harvesting. The stormwater fee has led to the successful use of green infrastructure at the parcel or site-level as shown in Figure 2.1.A-C. For developments after 1990, such as Potsdamer Platz, GI stormwater solutions have ensured that no stormwater is generated on parcels of land. Rather, water is attenuated in the landscape, or in designated stormwater attenuation ponds (see fig. 2.1A).

While GI is widely used to reduce stormwater inputs into the systems (such as those listed above), engineers such as Sieker (Ingenieurgesellschaft Prof. Dr. Sieker mbH) actively engage with developing new site-level solutions given local parameters and requirements. This includes solutions such as rain gardens or 'pocket wetlands' to reduce stormwater run-off and regulate traffic flow (fig. 2.1.B), and bioswales or strip gardens to replace traditional stormwater gutters (fig. 2.1.C).

To support the uptake of designed grey-green design solutions, the USA Environmental Protection Agency (EPA) has developed (and showcased) a collection of design tools and implementation records to assist with the development of fit for purpose grey-green design solutions for site developers and stormwater engineers (EPA, 2014b). Noteworthy design manuals found on their website relate to the development of GI solutions at the street-level, energy efficient urban developments, and enhancing existing stormwater infrastructure through GI (EPA, 2014b). These design manuals form part of an emerging evidence base towards promoting the use of grey-green solutions in urban planning.

Table 2.2: Overview of traditional grey infrastructure solutions and their alternatives

SOURCE: The Scottish Government, 2011

Traditional grey infrastructure solutions	GI alternatives
Road bollards	Street trees
Traditional roofs	Green/living roofs
Traditional flooding solutions – concrete channels, pipelines, etc.	Sustainable urban drainage, swales and the use of natural features for flood management
Standard road and stormwater infrastructure	Permeable paving incorporating water storage in the street sub-base
Single function rainwater pipes	Multi-functional swales, wetlands, natural watercourses, stormwater ponds and wetlands, construct infiltration and sand filters, natural buffer strips and bio-retention structures

Figure 2.1: Overview of grey-green design solutions used to manage stormwater and enhance overall environmental quality in greater Berlin, Germany.

Photograph by: Kerry Bobbins

(A) Stormwater attenuation pond built as part of the Potsdamer Platz development;
(B) Pocket wetland developed to attenuate stormwater and regulate the flow of traffic; and,
(C) Bioswales or strip gardens along a road to manage stormwater runoff.

2.4.2. Stakeholder inputs

The development of a GI planning approach should include inputs from a variety of sectoral and disciplinary stakeholders such as academics, researchers, civil society, government officials, and corporate entities (Lovell and Taylor, 2013). This allows for the increased quality, acceptance, and legitimisation of GI planning and implementation (Wilker et al., 2015). It also serves to unify stakeholders who support different policy agendas and allows for GI programmes to cut across portfolios (due to its cross-cutting benefits) related to natural resource management, nature conservation, landscape, recreations, public health and urban regeneration (Muradian and Rival, 2012; Wilker et al., 2015).

Stakeholders involved the development of a GI programme should include those that rely on the natural resource base (directly or indirectly), and those that are involved in the management or allocation of utilities and services (planners, engineers, government officials) (Muradian and Rival, 2012). Towards gaining the full scope of stakeholder insights it is stressed that all identified stakeholders should be included in all aspects of the GI planning process - in its conception, design, evaluation and implementation – to ensure that the ambitions and ideals of all stakeholders are captured in the final GI output (Mell, 2008; Muradian and Rival, 2012).

Although not covered in detail here, many academic texts address how public participatory planning processes can be undertaken. In particular, these texts mention the stakeholders that should be invited to attend these sessions, how a collective project goal is developed, and how responses come together in a final product or output. Noteworthy papers on one or many of these topics include Benedict and McMahon (2002), Muradian and Rival (2012), Anderson et al. (2013), and Lovell and Taylor (2013).

“In particular, there has been growing interest in economic valuation over the past ten years and this has been the core focus of many environmental evaluation studies undertaken in cities and regions around the world.”

2.4.3. Valuing green assets and infrastructure

Various efforts have been made to value ES to support the inclusion of GI in policy and planning (Daily et al., 2009). The premise of this work is to assign a value to ES – through a range of market-based approaches, tools and methods – to necessitate its inclusion in policy and planning alongside the services provided by traditional grey infrastructure (Muradian and Rival, 2012; URBES, 2013c; Haase et al., 2014).

In particular, there has been growing interest in economic valuation over the past ten years and this has been the core focus of many environmental evaluation studies undertaken in cities and regions around the world. Not only are the produced goods or services of particular interested in these studies, but also the benefits and losses associated with them (Vandermeulen et al., 2011). Studies by Costanza et al. (1997 and 2014) are worth mentioning here, as they have both shaped the desire to value ES using monetary terms and identified the fundamental challenges with this same approach. It has been identified that two core challenges remain around the development of valuation methods to assess ES (Costanza et al., 2014; Haase et al., 2014). Firstly, there are insufficient indicators to assess the real value of ES (i.e. which indicators and which stakeholders to accommodate) and secondly, the multiple functions of ES have not yet been successfully included in valuation studies to decision-making (Costanza et al., 2014; Haase et al., 2014).

Braat and De Groot (2012) posit that a collective decision on how to value ecosystems and their services is necessary. This type of decision will inform the kind of valuation methodology used and determine how best to value ES using existing infrastructure management frameworks (see Section 2.4.2) (Braat and De Groot, 2012).

Photograph by Brenden Gray

Box 2.2: Do we know the true value of urban trees in the City of Johannesburg?

Johannesburg's earliest planted trees date back to 1863 when the Bezuidenthout family planted fruit trees in what are now the areas of Judith's Paarl and Cyrildene. From as early as 1886, farmers along the Witwatersrand ridge brought oak and walnut seeds from the Cape to plant along the ridge. In 1886, the first plantations of wild acacia, teak, olive, tambotie, beech, ebony, mimosa and quince were grown. Suburbs such as Emmarentia soon became leafy after pavements were planted with oak trees. Street trees, mainly oaks, planes and pepper trees were planted particularly in Parktown and Westcliff. As the suburbs expanded, the British planted trees that were familiar to the English landscape (oaks, planes and jacarandas), and can still be seen in the city today.

Red gum trees, oaks, pines and wattles were also planted in the now Saxonwold area and were used as mine props. Blue gums were also used as mine props, and were planted in Saxonwold, Parktown, Langlaagte, Craighall and Fairlands. There are an estimated 1.2 million trees located in parks and on pavements in Johannesburg, and 4.8 million in private gardens (estimates based on 1996 figures).

As a significant part of urban infrastructure, trees fulfil a number of functions and roles in cities and have a real and calculable value (Moore, 2012). For example, the mature tree valuation studies conducted by Moore (2012) estimated that the value of a tree is far greater than that of its pure aesthetic value or replacement cost.

According to the replacement cost method of valuation, the value of a tree can be calculated by the cost to replace it. For example, based on the values calculated by Trees South Africa (2013), the cost of purchasing a tree is defined by the tree height, and its delivery and aftercare costs. To purchase a 10m tree and have it planted within 30-70km of the nursery, and adding 12 months of aftercare treatment, amounts to an estimated R54 400.

Table 2.3: Cost of purchasing and installing a 10m tree.

Values broken down per line item.

Item	Cost
Mature tree at 10m tall (4 500l)	R40 000*
Delivery and installation with staking	R7 450
Digging and planting the tree	R2 150
Aftercare services for 12 months at one a month	R4 800 (R400 per visit)
Total	R54 400

*Prices exclude VAT and are generalised values based on figures provided from Trees South Africa (2013) that are subject to change. Prices are based on delivery location being approximately 30-70km from the nursery.

Moore (2012) proved that by valuing the services provided by trees, their value was much higher than their replacement cost. Based on Australian estimates, the shade from 100 000 trees in an urban forest can reduce electricity costs for heating and cooling, and lead to an saving of $1 million (USD) per annum (Moore, 2012). It was also calculated that the shade produced by one tree, which can produce the same amount of shade as four sun parasails, can have a replacement value of $2 000 (USD) per annum (Moore, 2012). In addition, this same service can also extend the life of a tarmac and reduce maintenance costs over time.

The summarised historical information included in this box is sourced from City of Johannesburg (CoJ) (2003) and CoJ (n.d.), unless otherwise stated.

2.4.4. Data

Obtaining sufficient data to inform a GI planning approach is imperative for engaging a strategic vision, co-ordinating the use of resources, tracking improvements and anticipating the needs of future generations (Commission for Architecture and the Built Environment (CABE), 2009). Sufficient data to inform a GI planning approach would include the information on the spatial locations of individual green assets (in the form of an inventory or registry) or GI networks in the landscape. Without such data, it is not possible to plan and manage GI networks as green assets as their location and ES cannot be determined (CABE, 2009).

The lack of sufficient data to inform a GI planning process is a common concern among cities. An interesting case study is the UK where, in 2009, it was reported that "nobody knows how many green spaces there are, where they are, who owns them or what their quality is" (CABE, 2009: 4). This was because assets remained unmapped at the national scale and existing information and data was fragmented and unreliable (CABE, 2009). However, since 2009 significant data collection and sharing has commenced. This emerging body of data on green assets has underpinned a dramatic uptick in the number and quality of available GI-related datasets in England over the last few years that has subsequently supported the uptake of a GI planning approach. In addition, stakeholder networks have been developed in the UK to support the uptake of GI planning using approaches such as the GI Think Tank (GrITT), the prototype GI Valuation Toolkit and the GI Partnership. This has further facilitated the development of data through the creation of guidelines and stakeholder support (Green Infrastructure North West, 2009; Green Infrastructure Partnership, 2014).

The GI information gap can be overcome through the collection, collation and housing of existing environmental data in a centralised repository. This will support the use of this data and illustrate its value for environmental decision-making. This repository can be organised as a single national data repository which houses and shares digital spatial data and ensures that data are collected and categorised in a standardised way (CABE, 2009). Despite it not being considered a formal planning tool to guide GI planning in explicit terms, the Green-Space Information System (GRIS) (Grünflächeninformationssystem) in Berlin (Germany) is an example of a database that may hold vast potential for informing GI planning. GRIS is an environmental asset database that includes green assets such as urban green spaces and land registers (Senate Department for Urban Development and the Environment, n.d.). The database is populated, maintained and housed by the Senate Department for Urban Development and the Environment (Berlin's city planning department) and is used by planners and government officials as a tool to inform environmental target setting.

2.5. Focus and structure of GI plans

GI planning programmes have been used to fulfil a wide array of urban functions by placing a core planning focus on biodiversity, climate change, and sustainable infrastructure (Mell, 2012; The URBES Project, 2013b). Roe and Mell (2013) indicate that the concept of GI has been readily incorporated into urban planning in the UK, USA and Europe to attenuate floods, reduce the urban heat island effect, save energy, improve air and water quality, and increase cultural values and food security (Table 2.4).

The sections to follow introduce the focus and function of such GI plans and present on some the possibilities for the GI concept to be included into urban planning in the GCR (Table 2.5). Noteworthy plans include the NYC Sustainable Stormwater Management Plan, Green City Clean Waters, The All London Green Grid, and Community Green, which all meet the key priorities of the GPD, to be explored in more detail in Section 2.6.

Table 2.4: Overview of the functions of GI incorporated into many GI planning programmes in the UK, USA and Europe

ADAPTED FROM Roe and Mell, 2013

Planning programmes	Functions
Climate change adaptation and mitigation	Flood alleviation, cooling of urban heat islands and carbon capture
Climate control	Microclimate control, energy savings, atmospheric purification and particle control
Water cleansing and control	Filtration, absorption and transpiration
Economic development	Attracting business, tourism, improved quality of life and raising house prices
Sustainable transport	Improved access
Improving community cohesion	Creation of public spaces
Providing leisure and recreation opportunities	Outdoor relaxation
Reconnecting people with nature	Space and habitat for wildlife and increase access for people to visit natural habitats
Learning opportunities	Environmental education, involvement and training
Local food production	Allotments, gardens, urban agriculture and job creation
Improving health and wellbeing	Lowered stress levels, psychological wellness and providing opportunities for recreation (sporting and exercise)

Table 2.5: Overview of select green infrastructure plans and guidelines and how they have been designed to address key issues in cities and city-regions

Name of the GI plan	City/ country	Key focus	Source
The All London Green Grid	London, UK	Greening urban environments to conserve and increase access to nature, adapt to climate change and its impacts, and encourage healthy living.	Greater London Authority (2011)
NYC Sustainable Stormwater Management Plan	New York, USA	Create combined grey-green infrastructure to address water quality challenges linked with the combined stormwater and sewerage system.	NYC (2009)
Ecological Region	Paris, Île-de-France	Decision-making tool for the acquisition, development and management of green spaces to encourage the inclusion of biodiversity in planning, to support the provision of urban food production, and climate change adaptation.	Metropolis (2011)
Community green: Using local spaces to tackle inequality and improve health	London, West Midlands and Greater Manchester, UK	Importance of urban green space for human health and wellbeing, social cohesion opportunities through GI to reduce inequality.	CABE (2010)
The value of GI: A guide to recognising its economic, environmental and social benefits	Mixed applications, USA	Enhancing the mixed benefits of GI in urban contexts including economic, environmental and social benefits, with specific focus on the reduction of stormwater runoff, energy use, improved air quality, reduced CO_2, urban heat island effect, increased community liveability and improved habitat.	Centre for Neighbourhood Technology and American Rivers (2010)

Name of the GI plan	City/ country	Key focus	Source
Green City Clean Waters: The City of Philadelphia's programme for combined sewer overflow control	Lancaster, USA	Enhance watersheds and catchment areas by managing stormwater with innovative GI to meet urban demands in a cost-effective manner.	Philadelphia Water Department (2014)
LIFE: Building up Europe's GI. Addressing connectivity and enhancing ecosystem functions	European regional programme	Combat biodiversity loss through increasing the connectivity of green networks, strengthening the functionality of ecosystems for delivering services to manage the effects of climate change, increasing resilience of natural systems, promoting integrated planning, and contributing to a greener economy.	European Commission (2010)
Copenhagen Climate Change Plan and Cloud Burst Management Plan 2012	Copenhagen, Denmark	To attenuate the effects of extreme rainfall events and to devise more affordable and efficient stormwater management alternatives. These include new blue and green oases and recreational areas that can be constructed by combining ground level measures with plants and trees.	City of Copenhagen (2011 and 2012)

2.5.1. Sustainable stormwater management

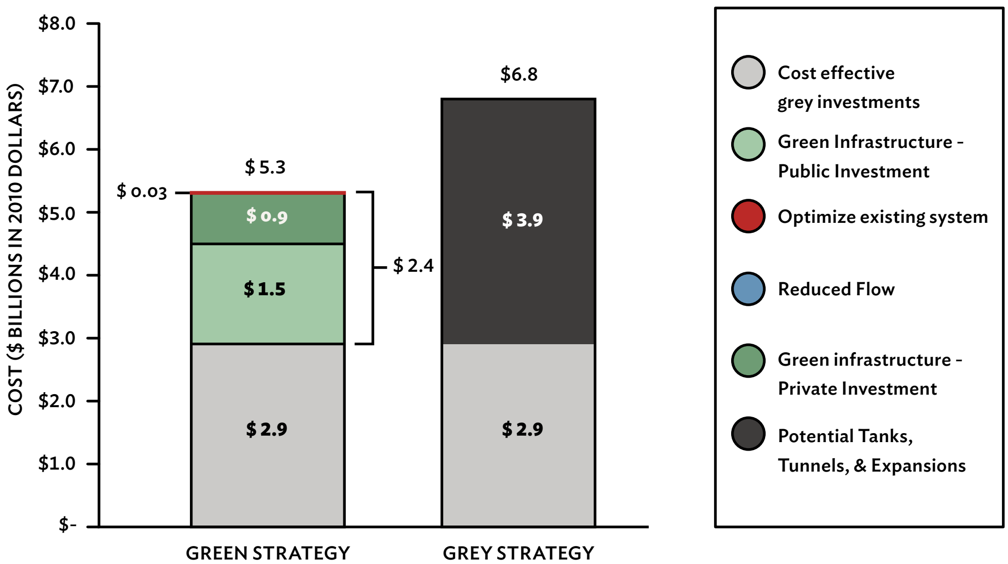
The GI plans for NYC (New York) and Lancaster (Pennsylvania) have a particular focus on improving the quality of stormwater through the provision of sustainable infrastructure. In NYC, for example, the use of GI stormwater solutions (blue and green roofs, porous pavements, swales, tree pits, constructed wetlands and rain barrels) opposed to an all-grey infrastructure approach, can result in a saving of $1.5 billion (USD) on water management over a 20-year period (NYC, 2009) (Figure 2.2). In addition, taxpayers could receive further benefits associated with the multi-functional services provided by GI in the range of $139 million - $419 million over the same period, including other complementary benefits such as reduced energy consumption, increased property values and improved public health (NYC, 2009).

To implement the GI Plan, NYC has devised a set of goals (short, interim and long-term) to sensitise stakeholders to an alternative infrastructure planning approach and demonstrate the cumulative benefits of GI. For example, the city aims to collect the first inch of rainfall that falls on 10% of its impervious surfaces by 2030 through increased infiltration and the use of GI. To meet this overall goal by 2030, the city has set about incremental shifts over time – 1.5% of all impervious surfaces by 2015, 4% by 2010, 7% by 2025, and 10% by 2030 (NYC, 2009).

In addition, NYC has made the necessary financial arrangements to support the development its GI plan. A GI fund was set up to support spending on the design, implementation and maintenance of GI interventions over the duration of the programme. The amounts allocated to this account were $1.5 billion (USD) over a 20-year period, and an additional $187 million (USD) in the form of capital funds (NYC, 2009). The funds were also split into the capital and operational expenditure for the duration of the scheme.

Figure 2.2: Cost scenarios for a green versus grey stormwater infrastructure approach in NYC. Costs calculated over a 20-year period

SOURCE: NYC, 2009



The Lancaster GI plan includes green roofs, tree planting, permeable pavements, bio-retention and water harvesting (EPA, 2014a). It was calculated that including GI approaches would lead to a reduction of $120 million (USD) in the capital costs of implementing grey infrastructure and avoided operational costs of $661 000 (USD) per annum (EPA, 2014a). These benefits are calculated over a 25-year implementation timeframe (EPA, 2014a). More of this work can be found in the NYC Sustainable Stormwater Management Plan (NYC, 2009) and the City of Philadelphia's programme for combined sewer overflow control (Philadelphia Water Department, 2014).

2.5.2. Climate change adaptation and mitigation

The projected frequency of natural disasters has encouraged cities to adapt to the impacts of climate change. This includes reducing greenhouse gas emissions, lowering the remediation costs of damaged public and private assets, and reducing flood risk. For example, increased instances of flooding in the City of Copenhagen have resulted in the significant damage of public and private assets (City of Copenhagen, 2011 and 2012). Planning in the city is now undertaken in accordance with a GI strategy (through the use of grey-green engineered solutions) to encourage the management of urban infrastructure and services in line with local catchment areas (and sub-catchments) to reduce flood risk (Leonardson, 2014). Further detail can be found in the Copenhagen Climate Change Plan (City of Copenhagen, 2011) and Cloud Burst Management Plan (City of Copenhagen, 2012).

2.5.3. Improved community cohesion

A study conducted by the CABE (2010) for London, West Midlands and Greater Manchester emphasised that where individuals perceive green space to be of a good quality, they are more satisfied with their neighbourhood and enjoy better health and wellbeing. The study also demonstrated that green space plays a positive role in easing racial tensions and bringing together diverse groups of people through providing informal areas for recreational sports, as well as organised and casual encounters (CABE, 2010). The improvement of green spaces in the UK, through various GI-related programmes, has led to the increased use of parks by people in urban areas (CABE, 2010). Further detail on the CABE studies can be found in the report entitled *Community green: Using local spaces to tackle inequality and improve health* (CABE, 2010).

2.5.4. Reconnecting people with nature

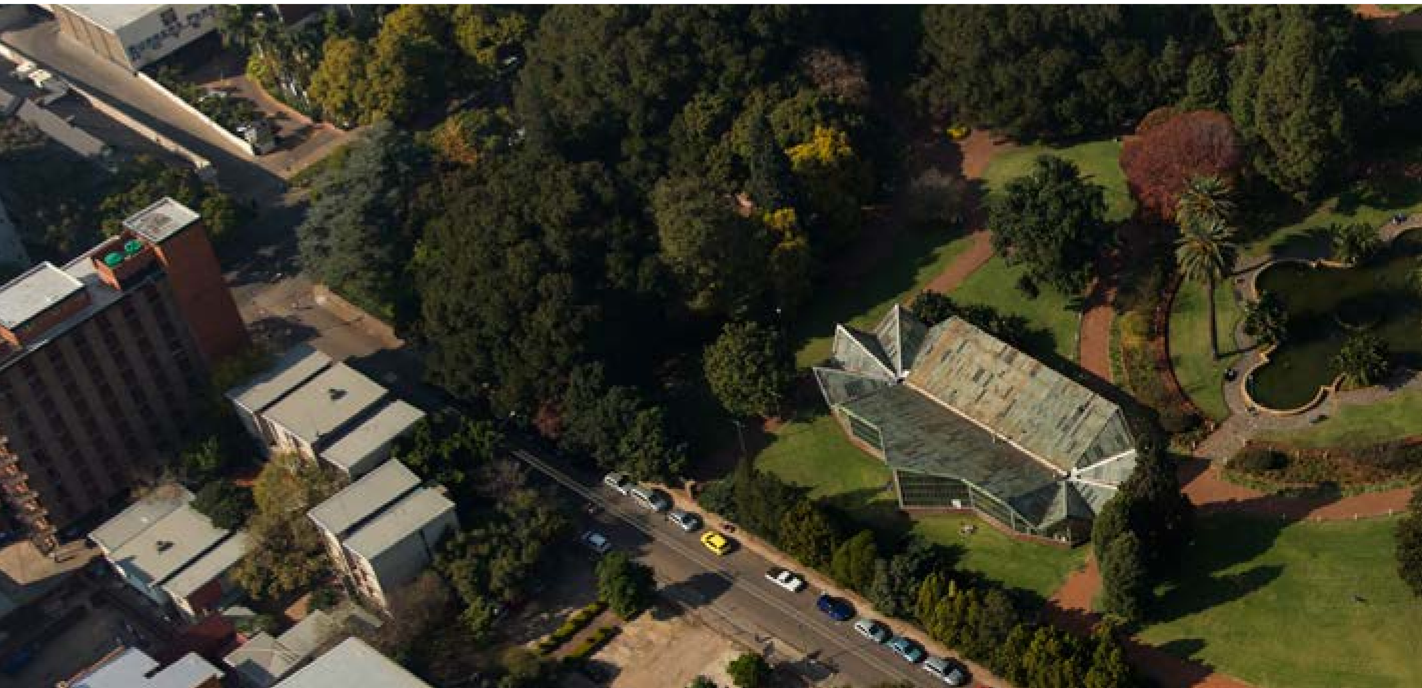
The All London Green Grid (Greater London Authority, 2011) and the European Commission's GI project called LIFE (European Commission, 2010) aim to reconnect fragmented parts of the natural landscape to preserve and protect the natural resource base. These plans are developed on the premise that a society that is well connected with nature has a higher quality of life and is happier in general. The extension and provision of public green spaces in urban areas are also used to combat urban challenges such as air quality and heat island effects. Maps and information on these plans can be found in the relevant reports by the European Commission (2010) and Greater London Authority (2011).

2.6. Guiding the uptake of a GI planning approach in the GCR

The GCR already has a rich and diverse endowment of green assets, both natural and constructed (man-made), (with only 15% of the total land surface of Gauteng considered 'urban'). Much of the natural resource base is comprised by large stocks of natural and planted grasslands, non-indigenous forests and other vegetation (Figure 2.3). However, many natural areas are now in decline due to the threat of industrialisation, mining, agriculture and urban sprawl.

The GCR's population has grown faster than all other South African provinces and this has led to significant changes in land use. According to growth rates projections, Gauteng will have to meet the needs of 16 million people by 2025, and 20 million people by 2050 (GCRO, 2012). Rapid growth can be attributed to the GCR's relative success in creating jobs and providing basic services such as water, housing and sanitation compared to other parts of South Africa (Schäffler et al., 2013). As a result, the challenges facing the GCR are unique to the region and are a blend of both environmental and urban concerns, which can be further differentiated across its constituent municipalities.

Photograph by Clive Hassal



A number of key priorities areas have been identified for the Gauteng province and includes creating decent work; promoting quality education; prioritising healthcare; food security; reducing crime; building sustainable communities; and promoting good governance (GPG, 2009 and 2012). To meet these key priority areas, the GPD aims to invest in public infrastructure to encourage the sustainable use and management of natural resources, and address inequality in access to basic services (GPG, 2009). Investments in public infrastructure could be extended to include a focus on GI as a way to meet key priority areas.

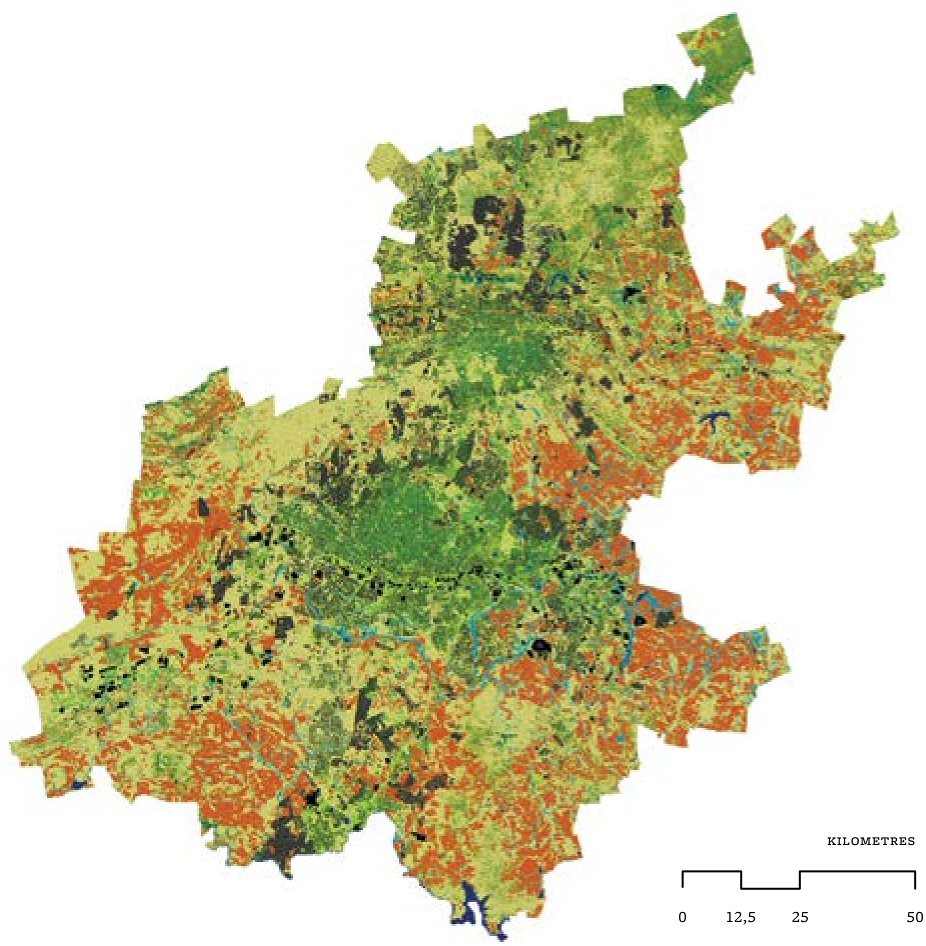
As explained earlier in this chapter, GI can be used as a novel planning approach to harness and extend the existing green networks in cities to provide much needed urban infrastructure and services. A GI planning approach can offer the GCR a possible strategy for meeting key priority areas for the province, while also creating more sustainable urban landscapes. Examples outlined in Section 2.5 indicate that a GI planning approach has allowed other cities around the world to address similar priority concerns.

More specifically, a GI planning approach can provide opportunities in the GCR for:

- Meeting the demands for basic services and upholding human rights;
- Allowing for the provision of services through enhancing the connectivity of green networks;
- Using existing budgets dedicated to environmental and infrastructural departments to meet the growing demands of society, environment and economy;
- Increasing quality of life;
- Offsetting the costs of traditional grey infrastructure approaches through creating combined grey-green engineered solutions;
- Reducing the purification costs of water through the use of ES and increasing the ambient air quality of cities and urban nodes;
- Reducing the *in situ* effects of urban pollution and its effects on the city-region as a whole through the use of ES;
- Combining planning and environmental projects at the local level to inform more cost-effective and holistic planning; and
- Increasing urban resilience and opportunities for adaptation and mitigation of the effects of climate change.

Figure 2.3: Overview of Gauteng's land cover

DATA SOURCE: Geo-Terra Image (GTI), 2012



- Urban: Buildings, sports stadiums, industrial, residential, township, new development, villages, small holdings, roads and railway lines
- Trees (indigenous)
- Trees (non-natural)
- Thicket, bushland and bush clumps
- Grassland (natural and planted)
- Degraded natural vegetation
- School grounds, sports and recreation areas and golf courses
- Cultivated land
- Small holdings
- Bare rock and soil
- Open space
- Wetlands
- Water
- Mines and quaries

2.6.1. Existing policy focus on ecological infrastructure

The guiding principles of the National Development Plan (NDP), South Africa's primary integrated planning document and long-term perspective, encourage harnessing the potential of its existing natural resources, and supports transitions to a sustainable, climate resilient and low carbon society (Department of Environmental Affairs (DEA), 2014). Through the concept of ecological infrastructure, the South African National DEA and South African National Biodiversity Institute (SANBI) promote the idea of restoring, maintaining, and enhancing existing ecosystems for the services they provide to society (SANBI, 2011). At present, ecological infrastructure is being considered as one of South Africa's national Strategic Infrastructure Projects (SIP) (SANBI, 2011).

In order to meet the requirements of SIP, the National Treasury has instituted a Chief Directorate dedicated to the integration of the economy and the nationalisation of The Economics of Ecosystems and Biodiversity (TEEB), which is a global initiative that emphasises the economic benefits of biodiversity and the cost of biodiversity loss (TEEB, nd). The approach undertaken by the DEA includes the following (DEA, 2014):

- To encourage ecosystem assessments at multiple scales;
- To enhance the value proposition of natural capital through sophisticated communication;
- To continue to mainstream across sectors;
- To further research on natural capital accounting; and
- To develop a suite of impact indicators to monitor and evaluate the science policy interface.

In South Africa, cities such as Cape Town and eThekwini (Durban) have started to develop ecological infrastructure plans to preserve and restore the natural resource base. For example, eThekwini, guided by SANBI, is currently heading up an ecological infrastructure project in the uMngeni River catchment located in KwaZulu-Natal. This project aims to enhance the services provided by ecological infrastructure in the catchment to improve the quantity of water delivered to eThekwini, and to promote sanitation services in general (eThekwini Municipality, 2007; SANBI, 2013).

The City of Cape Town is implementing a dune rehabilitation project to reduce damage to properties and infrastructure along the coastline (Chapter 3 of this Report). It is also worth mentioning that a similar project has been implemented in eThekwini, where natural shore breaks have been constructed to decrease the impact of storm surges on the coastline (eThekwini Municipality, 2007).

While ecological infrastructure plans (such as those introduced above) have initiated a shift in the way green assets are planned and managed in South Africa, their focus is limited to areas with high biological value or where ecosystems remain intact. As such, many degraded ecosystems (natural or urban) and urban green networks fall outside the focus of national environmental management strategies (such as those on ecological infrastructure) and this often sees much of this land earmarked for development. This is where the GCRO aims not only to build on the existing ecological infrastructure agenda, but extend its focus to consider the ES provided by degraded ecosystems and urban green networks.

> **"While ecological infrastructure plans ... have initiated a shift in the way green assets are planned and managed in South Africa, their focus is limited to areas with high biological value or where ecosystems remain intact."**

Photograph by SA Tourism

2.6.2. Opportunities for informing a GI planning approach in the GCR

Existing GI plans present on a set of lessons for developing and implementing a GI planning approach in the GCR. This section aims to touch on some of the opportunities of a GI planning approach as presented by existing GI plans covered in this chapter (Section 2.5).

As mentioned previously, the NYC GI plan offers insights on the uptake of GI stormwater alternatives in the GCR (NYC, 2009). Firstly, the costing of a GI approach versus an all-grey approach in this plan presents a convincing argument for encouraging the uptake of GI planning to support stormwater management. Secondly, the NYC GI plan is a prime example on how to balance the cross-cutting interests of a variety of stakeholders that may not traditionally fall within formal service-based planning.

In addition, the goal-based approach (setting of short, interim and long-term goals) proposed by the NYC plan also presents an opportunity for the rollout of GI in the GCR. This kind of incremental approach allows not only for governance structures to align with the new planning approach, but also for the benefits of the GI programme to accrue over time allowing the city to gain maximum benefit from GI .

As mentioned previously by the CABE (2010) study (Section 2.5), GI also creates a set of additional opportunities for managing green networks in a way that addresses deprivation from quality green space in urban areas. As municipalities in the GCR are already engaging with extending existing green space for the cultural and social services they provide (e.g. the Johannesburg Metropolitan Open Space System (JMOSS) plan), this presents one opportunity for extending green networks and providing ES to meet key social challenges – or to piggyback onto existing departmental projects. The *proviso* here is that these assets are already included in existing municipal finance systems, and through ES valuation the cost-benefits of these assets can be used to motivate for increased funding for new parks and park maintenance.

2.6.3. Available data and other insights

The GCR already has a diverse set of existing digital spatial data on environmental features (Schäffler et al., 2013). Despite this, available data have not been shown to support the integrated planning of GI across the GCR. This is primarily due

to the following:

- Existing data on GI are housed across a multitude of national, provincial and local departments which makes the data difficult to source, collate and share;
- Data on GI are often created according to specific mandates at a national, provincial and local level and this rarely allow for data to be compared across various temporal and spatial scales; and
- Environmental monitoring and evaluation data at the national, provincial and local level are often not accessible to the public and other stakeholders despite it being collected regularly by various government departments, parastatals and non-governmental organisations.

Access to robust data such as GRIS (covered in Section 2.4.4) can enhance the effectiveness of GI planning in the GCR and assist stakeholders to better manage the services provided by green assets. Towards achieving a data repository such as GRIS, the Gauteng GIS Forum, which aims to centralise the housing and sharing of provincial and municipal GIS data to support government decision-making, can be used to develop a similar data repository in Gauteng (GPG, 2015). This forum can be used to guide the collection, sharing and housing of environmental data in the GCR, allowing available funds allocated to data (collection and maintenance) to be spent more effectively. As the importance of data on GI grows in the GCR, the forum can facilitate GI planning over time (such as the UK case study presented in Section 2.4.4), opening up further opportunities for the development of stakeholder networks.

There are also a number of international benchmarking datasets that may support a GI planning approach in the GCR. An example of such datasets is park data generated by the Yardstick benchmarking programme (described in more detail in Box 2.3). This programme highlights that municipalities in South Africa are responsible for maintaining a wide variety of public open space types such as natural, maintained parks and sports parks, and this data can map funds spent on parks against their associated ES. A similar mapping can be done for other municipal park assets such as trees, playgrounds and youth facilities, paths, furniture and gardens. For example, Yardstick data presented in Table 2.6 show that the CoJ and Ekurhuleni Metropolitan Municipality (EMM) have a significantly higher allocation (or number) of parks to maintain compared to the City of Cape Town (CoCT). This data could be used to measure allocated budget according to available ES in each of these municipalities.

Table 2.6: Overview of municipal statistics from the Yardstick benchmarking programme for CoJ, EMM and CoCT

	CoJ	CoCT	EMM	Source
Total area of parks	9 248	4 494	8 909	Yardstick (2010)
Hectares of parks per 1 000 residents	2.87	1.55	3.59	Yardstick (2010)
Hectares of natural park per 1 000 residents	0.98	0.89	0.85	Yardstick (2010)
Hectares of actively maintained park per 1 000 residents	1.89	0.66	2.75	Yardstick (2010)
Total operating costs – direct annual operating expenditure of parks (ZAR)	R270 640 000	R323 431 809	R352 803 374	Yardstick (2011)
Total operating costs – total annual direct operation cost per 1 000 residents (ZAR)	R83 911	R111 788	R142 243	Yardstick (2011)
Trees expenditure – total cost of tree maintenance (ZAR)	R18 611 000	R11 700 002	R1 620 000	Yardstick (2011)
Trees expenditure – tree maintenance cost per 1 000 residents (ZAR)	5 770	4 044	653	Yardstick (2011)

"... GI has the ability to alter the way in which urban landscapes are perceived and managed in the GCR and presents a planning opportunity to meet its developmental priorities."

Box 2.3: Yardstick park benchmarking programme

The Yardstick programme was initiated in New Zealand in 2001 and was quickly extended to include other countries around the world, including Australia, South Africa, Swaziland, Canada, Finland, Denmark, Norway and Ireland. It currently has around 120 participating parks organisations.

Each year an online form is made available to subscribing organisations requesting detailed information about their park and asset provision (e.g. playgrounds, gardens, paths), financial information, operations, policy and strategy development. A comprehensive set of guidelines has been developed to help determine what to include and exclude from each response, as well as an on-site annual audit of the information to help validate the responses.

All text derived from direct contact with Jayson Kelly, director of the Yardstick programme (Kelly, 2014)

2.7. Conclusion

The growing theoretical and applied literature on GI and the existing GI plans provide insight on how green networks have been used in cities around the world to meet a wide array of urban-based functions, such as attenuating floods, reducing the urban heat island effect, improving air and water quality, and increasing cultural values.

As presented in this chapter, many theoretical texts discuss the conceptual underpinnings of a GI approach using the core principles of multi-functionality, connectivity and scale (Section 2.3), however there remains a limited understanding of how this concept can be successfully applied in the GCR context. Towards addressing this gap, Chapter 2 has presented a conceptual foundation for developing a GI plan in the GCR by introducing the core concepts that underpin a GI planning approach (Section 2.3), explained the broad focus and function of a GI plans (Section 2.5), and highlighted some of the opportunities for using GI to meet some of the priority areas of government (Section 2.6). More specifically, this chapter has drawn together some key insights from a variety of authors, projects and studies and, by doing so, has extended the conceptual foundations laid by SoGI.

Photograph by Clive Hassal

Illustrated by noteworthy GI applications in London (UK), NYC (USA) and Copenhagen (Denmark) (explored in more detail in Section 2.5), GI has the ability to alter the way in which urban landscapes are perceived and managed in the GCR and presents a planning opportunity to meet its developmental priorities. In particular, the NYC GI plan offers insights on the development of incremental GI planning goals and financing methods – primarily through the development of a goal-based GI plan and a dedicated GI fund (NYC, 2009). More specifically, the costing of the benefits of GI stormwater interventions alongside a traditional approach is likely to present a convincing argument for city officials, planners, and budget managers. In this regard, local opportunities also exist for extending the GI agenda. This includes the national focus on ecological infrastructure which can be extended and expanded to include urban green assets (and degraded landscapes) and their associated ES. The Gauteng GIS Forum also presents an opportunity for enhancing the collection, collation and housing of provincial environmental GIS datasets to support GI planning in the GCR.

Through assimilating various theoretical and conceptual literature, the following considerations present themselves as being central to the development of a GI planning approach in the GCR. These are: (1) identifying a common GI project goal and devising a clear vision for a GI plan; (2) involving a variety of stakeholders in the conception, development and implementation of the GI plan; (3) collecting and using robust environmental data to support GI planning (to manage the location and services provided by GI); and, (4) reviewing and revising the final GI plan to ensure that it continues to meet the overarching goal.

Towards advancing the case for greater adoption of GI in provincial and municipal planning in the GCR further work should be undertaken to support the findings of this chapter. This research needs to be designed to provide insights on how government can better make use of GI and to identify how it can gain traction in the GCR. More specifically, this should focus on ways to fund a GI planning approach in the GCR; scope opportunities for and barriers to a GI planning approach at the local government level; investigate opportunities for the efficient management of data on environmental assets; and, identify possibilities for the design and use of grey-green infrastructure in traditional infrastructure projects.

"... this should focus on ways to fund a GI planning approach in the GCR; scope opportunities for and barriers to a GI planning approach at the local government level; investigate opportunities for the efficient management of data on environmental assets; and, identify possibilities for the design and use of grey-green infrastructure in traditional infrastructure projects."

Photograph by Clive Hassal

Part B

Expert insights into applying a green infrastructure approach

This section presents the three commissioned pieces that consider how green infrastructure (GI) and ecosystem services (ES) can be valued by municipalities, and how grey-green design solutions could be implemented in the Gauteng City-Region (GCR). The first piece, written by Anton Cartwright and Gregg Oelofse, reflects on the City of Cape Town's (CoCT's) experience in trying to mainstream GI into municipal structures and planning through the use of financial valuation of ES. The second piece, written by Miles Mander, draws on experiences in implementing a social learning process of appreciating – and developing an appreciation for – the value of GI and ES, which goes beyond the financial valuation techniques traditionally used to value ES. The final piece, by Stuart Dunsmore, explores various GI alternatives and identifies a range of challenges and opportunities for GI in Gauteng, drawing on interviews with municipal officials across the city-region.

The original pieces have been edited to conform to the format of this Report. The original pieces can be accessed from the GCRO's Green Assets and Infrastructure project web page (www.gcro.ac.za/project/green-assets-and-infrastructures.)

3. Reflections on the valuing of ecosystem goods and services in Cape Town

WRITTEN BY ANTON CARTWRIGHT AND GREGG OELOFSE***

3.1. Introduction

In 1987, the Brundtland Commission claimed that "...the environment is where we live; and development is what we all do in attempting to improve our lot within that abode. The two are inseparable" (Brundtland et al., 1987: 14). This was a deliberately bold statement that was aimed at shifting the predominant view of the environment, which is considered to be a subsidiary of the economy, and recognising the extent to which societies and economies depend on functional environmental systems. The Brundtland perspective has been widely endorsed for two and a half decades, but it has not gained significant economic or legal traction (Sagoff, 2012). In an attempt to address this key challenge, two related strands of economic research have sought to provide monetary quantifications of environmental value.[1]

* Mistra Urban Futures Researcher, African Centre for Cities
** Environmental Resources and Management Department (ERMD), City of Cape Town
1. In September 1982 a group of economists gathered in Stockholm to confront the implications of environmental degradation and scarcity for the discipline of economics. While this was by no means the first application of economics to environmental issues, it marked the beginning of formal recognition for the ecological economics discipline.

> **…the environment is where we live; and development is what we all do in attempting to improve our lot within that abode. The two are inseparable**
>
> (BRUNDTLAND ET AL., 1987: 14)

Photograph by Potsiso Phasha

"Climate change has also focused environmental research on cities as a locus from which environmental damage emanates, and where climate change risks coalesce and costs are incurred."

The first strand of economic research focuses on the economic cost of environmental degradation. For example, an early study calculated that the cost of noise pollution to properties in the flight path of Gatwick airport was in the region of £1 460 (R26 268)[1] on the value of a home worth £100 000 (R1.7 million) (Jacobs, 1991). In a 2010 World Bank study, it was estimated that the cost of adapting to a 2°C warmer world by 2050 would be in the region of $70-100bn (USD) (R804 billion - R1.1 trillion) per annum, with 80% of this cost being borne by people located in the cities of developing countries. In Cape Town, a similar study was conducted in 2008 on the impacts of sea-level rise along the city's coastline. It estimated that the cost of storm surge and sea-level rise risk over the ensuing 25 years would be between R4.9 billion and R20.2 billion, depending on the magnitude of the rise (Cartwright, 2008).

The second strand of economic research has focused on placing monetary values on environmental assets and the services provided by these assets. A 2010 report compiled by The Economics of Ecosystems and Biodiversity (TEEB, 2010) placed monetary values on a range of ecosystems and environmental assets. For example, the report estimated that the value of Hawaii's coral reefs is $2 168 (USD) (R24 900) per hectare per annum[2], and the climate change benefits of halving the current global deforestation rates at $3.7 trillion (USD)[3]. A seminal piece of work in this field was published in Nature by Robert Costanza and a team of researchers in 1997 (Costanza et al., 1997). This paper assessed the value of 16 biomes and 17 ecosystem services (ES), in terms of current economic value. The estimated value across the range of assessed components ranged between $16 and $54 trillion (USD), and the average value per service or biome came to $33 trillion (USD). When the study was conducted, the global Gross National Product was valued at $18 trillion (USD). This work was noteworthy in suggesting that the value of ecosystem goods and services was greater than the stock of capital and flow of income produced by the actual economy, and pointing out that the majority of this value existed outside the market.

For both strands of economic research, the strategic focus is an effort to attract greater economic and policy recognition for the natural environment through presenting it as an asset and source of economic services. The underlying assumption is that unless the natural environment is given an economic value, financiers and planners will continue to discount the contribution of environmental goods and services in economic growth, economic resilience and human wellbeing. For ecologists, this perspective ignores the principles that govern the world's natural order. The Costanza et al. (1997: 253) paper highlights the concern that "[b]ecause ES are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions." By valuing the environment using an economic value, it is hoped that conservationists are able to compete with more conventional economic development projects on an equal footing.

More recently, climate change has provided fresh impetus for both the valuation of environmental goods and services, and the costing of degradation (see Stern et al., 2006). Climate change has also focused environmental research on cities as a locus from which environmental damage emanates, and where climate change risks coalesce and costs are incurred

1. Currency conversions reflect the exchange rates of when the chapter was written (2014).
2. Based on research by Cesar and Van Beukering (2004).
3. Based on work by Eliasch (2008). This figure was a Net Present value.

Photograph by SA Tourism

(Satterthwaite et al., 2009; Cartwright et al., 2012). In spite of this impetus, it is not obvious that either the valuing of the natural environment, or the costing of its degradation is effective in ensuring that decision-making imputes the reported values. Understanding the reasons for this is important for the appropriate use of economic evaluations.

This chapter draws on the experience of valuing ecosystem goods and services in Cape Town using insights from these two strands of economic research to elucidate the role that ecosystem valuation can play in influencing decision-making at the local level.

3.2. Cape Town's valuation of ecosystem goods and services

The City of Cape Town Metropolitan Municipality (CoCT) is internationally renowned as a place of natural beauty. The aesthetic appeal of the city is underpinned by the iconic Table Mountain National Park (one of the initial five global biodiversity hotspots identified by Conservation International in 1989) that includes nearly 300 kilometres of coastline and a complex riparian and wetland system. In spite of CoCT's status as a leading city for addressing climate change in the Global South (Cartwright et al., 2012) and the seemingly obvious importance of Cape Town's natural environment for the city's economy and global desirability, the investment, management and protection of Cape Town's natural assets remains substantially under-resourced. In addition, the Environmental Resources and Management Department (ERMD) is responsible for environmental management in the CoCT and has historically been peripheral to the municipality's governance.

A degree of this marginalisation has been the ERMD's own making due to the staff's disciplinary grounding in conservation biology. This has at times proven difficult to reconcile with CoCT's pressing demand for housing, and social and economic development because the approach taken by ERMD has only reinforced the perception that environmentalists are anti-development as they prioritise "blomme voor mense".[4] The Statistics South Africa (StatsSA) Census 2011 data confirmed that an estimated 50 000 job seekers have migrated to Cape Town on an annual basis over the last decade (from within and outside South Africa). In response to this, ERMD has unwittingly positioned itself as the last line of defence between the land, infrastructure and service needs of Cape Town in its growing and increasingly affluent (in parts) population, and in the protection of the city's natural environment. In an attempt to better

4. Translated to English from Afrikaans to mean "flowers before people" in a manner that impeded development and poverty alleviation.

understand ERMD's approach, it should be appreciated that during the period shortly before and after the first democratic election in 1994, environmentalism in South Africa found a new expression through political activism and social mobilisation (Patel, 2009). The use of emotive campaigns and messages of pending doom for charismatic mega-fauna and flora was consistent with the general approach applied to policy development at the time as South Africa sought to rewrite its legislation and reconfigure its priorities (Reed and De Wit, 2003). Concepts of environmental justice have endured in ERMD and this approach has proven to be a barrier to linking bureaucratic planning and sustainable urban development. Integration at the local level has not been assisted by the ambiguity that exists around the environmental management roles of South Africa's three spheres of government (De Visser, 2012). The primary environmental responsibility resides with national government, with devolution of certain mandates to provinces and local municipalities respectively. For ambitious environmental units within local governments, the limitations placed on them by provincial and national departments can be a source of frustration, particularly when used as a reprimand for proactivity.

The ERMD's effort to place economic values on environmental resources in Cape Town has informed part of the department's own process of acknowledging its history and involvement in CoCT endeavours. In particular, the ERMD has recognised that the development versus conservation stand-off that has emerged was not only unproductive, but it also foreclosed opportunities. The subsequent efforts to address this have encompassed the valuation of natural capital, including Zandvlei Estuary and Reserve (Turpie et al., 2001), ecosystem goods and services (De Wit et al., 2009), the baboon population (Van Zyl and Barbour, 2013) and the risk of anthropogenically perturbed climates (Cartwright et al., 2012).

This section reflects on the experiences of one of those studies, entitled *Investing in natural assets. A business case for the environment in the City of Cape Town* (De Wit et al., 2009). This study set out to value Cape Town's natural environment and establish the economic consequences of greater investments in the natural environment. Within the context of the strategic shift by ERMD, the commission of this study was motivated by a number of specific intentions:

- **Capturing attention and right-sizing:** It was inevitable that the valuation of Cape Town's ecosystems goods and services would yield large numbers. The hope within ERMD was that these numbers would be able to assist with raising the profile of the work undertaken by the department based on a heightened awareness of the true economic value of the city's natural environment.

Photograph by SA Tourism

- **Signalling a willingness to integrate and be integrated:** Through the adoption of an economic analysis, the intention was to signal ERMD's willingness to align with the economic decision-making in the city, including the sustainable use of Cape Town's natural resources in economic development.
- **Motivating for a maintenance budget:** Departments responsible for roads, stormwater, public buildings and transport in the CoCT conduct an annual inventory assessment of infrastructure under their management. The inventory value is used by these departments to make budget requests based on the need to maintain and replace infrastructure. By adopting the same approach, ERMD hoped to highlight the value under its custodianship, and to apply this value in a motivation for a greater portion of the local government budget. Best practise for infrastructure management suggests that between 2% and 4% of the asset value should be spent annually on maintenance. Linked to this was ERMD's claim that timely investments in ecosystem goods and services could reduce the maintenance cost of built infrastructure in the city by mitigating damage caused by floods, wind-blown sand and overburdening of water and energy infrastructure.
- **Identifying opportunities:** The work paid specific attention to potential economic growth as a result of fiscal allocations to ecosystem goods and services. This was a deliberate strategy of the ERMD aimed at highlighting the economic opportunities that could be unlocked through investments in ecological capital. In addition, it was hoped that the report would highlight the centrality of ecosystem goods and services to the livelihood strategies of poorer households in Cape Town.

3.3. Valuation methodologies

There is a variety of credible approaches to valuing ecosystem goods and services. However, all approaches assume that the final outcome will be a financial value. With regard to these methodologies, it is important that the assumptions are made explicit from the outset. In particular, any valuation of ecosystem goods and services should be transparent and specific on 'what', 'how' and 'for whom' considerations informing the valuation. The De Wit et al. (2009) study was explicit on these considerations, and the methods adopted were a key determinant of the results produced. The following sections explore these considerations further in terms of the CoCT study.

3.3.1. What is being valued?

Environmental valuations need to be clear on what is being valued. Ecological assets are not easily ring-fenced or commoditised as they are often only valuable as part of a whole functional system, and the services they provide tend not to be discrete. In their critique of environmental valuations, Vatn and Bromley (1994: 133) highlight the different ways that individuals can comprehend and articulate notions of the environment: "It is not stretching the point to say that the 'resource' in question could be practically anything the respondent – or the researcher – wants it to be". Moreover, defining the geographical boundary of the system is difficult[5] and distinguishing between the benefits arising from interconnected systems is almost impossible. The soil and the hydrological system, for example, is complicated by the nature of the interactions between systems. As a result, defining the object of valuation invariably involves a degree of contrivance – what Polanyi (1944) called commodity fiction[6] –and is innately subjective.

A common approach to defining what is being valued when looking at ecosystem goods and services involves drawing a distinction between:

- Environmental assets – capital stock of natural environment;
- Environmental goods – natural resources that have an obvious 'use value' such as fish, timber and water; and
- Environmental services – services and values derived from the environment such as flood buffering, temperature regulation and water

5. Such boundaries seldom accord with legislative boundaries.
6. Polanyi points out that the commodification of land in North America in the 17th century was an anathema to the Native Indians who believed people belonged to land, not the other way around.

"Environmental assets and the services they provide are not conventional economic goods, and they are not transacted in a manner in which the terms of trade are observable."

purification, as well as cultural, spiritual and 'sense of place' values. Inevitably, this allows the categorisation of these values to become contrived, and exposes the valuation to queries around what has been left out or double-counted.

The World Bank (working with the International Union for Conservation of Nature (IUCN) and the Nature Conservancy) proposed an approach for valuing ecosystem goods and services using the 'Total Economic Value' concept. This approach distinguishes between 11 goods and services provided by the environment and ten ecosystems that provide these goods and services. This approach is only one of a suite of similar methodologies developed since the late 1980s. The De Wit et al. (2009) study in Cape Town drew from the World Bank (2004) approach and clearly defined what the study set out to value. It focused on five ES as defined below:

- Natural hazard regulation (buffering function performed for flooding, fires and coastal surge/ sea level rise);
- Provision of natural characteristics that are conducive to tourism and recreation;
- The improvement of water quality and the assimilation of waste;
- Provision of space for globally important biota; and
- The aesthetics and sense of place provided by the natural environment.

3.3.2. How to value?

Once the purpose of the valuation has been identified, the next step is how to ascribe an appropriate value to the identified goods and services. Conventional economics relies on markets to provide prices as a proxy for value. This, however, creates a challenge for assets that provide multiple services. A single good can provide multiple uses (for example, butter can be a spread, used as a baking ingredient and a source of nutrition) and markets may charge consumers different prices for the same product based on the relative preferences of different communities. Over time and multiple exchanges, functional markets indicate the value that different sections of the public place on conventional economic goods. This is considered to be a reasonably accurate manner in which value is ascribed – or at least more accurate than a theorised estimate produced by a researcher or politician. Environmental assets and the services they provide are not conventional economic goods, and they are not transacted in a manner in which the terms of trade are observable. On the contrary, most environmental goods and services are consumed implicitly, not in formal markets, and are often considered free. This makes it difficult to gauge their value relative to other items even when they are used on a regular basis.

In the absence of ascribing prices in formal markets, environmental valuations rely on a range of techniques to infer, or elicit, values from users of the environmental good or service under question. These are used as proxy values that are then converted into monetary values as a matter of convenience. An overview of the suite of proxy pricing methodologies that can be applied to infer the value of ES is shown in Table 3.1. Each of the valuation methods outlined in the table has it strengths and weaknesses in different contexts (see World Bank, 2004; De Wit et al., 2009). Based on the strengths of these valuation methods for the local context, the CoCT study included a combination of hedonic pricing, contingency pricing and travel cost method techniques (De Wit et al., 2009).

The value of Cape Town's natural tourist attractions, for example, was calculated for 'low', 'medium' and 'high' scenarios based on a combination of gate levies to the city's natural tourism attractions, the amount spent by international tourists in getting to South Africa, and the proportion of those tourists (40%, 50% and 60% under the three different scenarios) who, in surveys, cite Cape Town's environmental resources as the reason for their visit. Similarly, the R2.6 billion (in 2009) 'expenditure

Table 3.1: Evaluation approaches for ecosystem goods and services

Evaluation approach	Principles behind the approach
Change in productivity	Trace the impact of a change in the environment on produced goods, or the illness and productivity of people.
Replacement cost	Based on the cost of replacing or restoring the damaged environmental system.
Hedonic pricing	Based on how damage manifests in the prices of things that contain elements of, or rely on the damaged environment.
Contingent valuation	Based on asking people what they would be prepared to pay (willingness to accept) for a particular service, to have a service restored or to protect a particular service. Alternatively, this can include asking how much people would need to be compensated in order to have a service removed (willingness to accept). Both contingencies should be adjusted for income, especially when comparing respondents of different income levels.
Choice modelling	Based on indicated preferences from amongst a set of alternatives, some of which have a known value.
Travel costs	Estimate value based on the amount people are prepared to pay to travel to a resource.

injection' provided by the film industry was assumed to be 5%, 10% and 15% attributable to Cape Town's natural environment (under different scenarios) and calculated accordingly. Through this approach, Cape Town's biodiversity was valued by adjusting and combining the proxy values of direct investments made by domestic and international conservation and research agencies – the portion of tourism revenue that could be attributed to Cape Town's natural assets.

Given that the natural environment provides benefit streams that accrue at different times, and often requires sustained investments or expenditure, the respective values need to be reflected as a current time amount – usually called Net Present Value – in order to enable decisions in the current period. Discounting future benefits and costs in order to reflect them as a present value is a common human attribute, but one that has a profound impact on valuations. The discount rate represents the percentage by which a value is reduced annually. The Cape Town study performed its valuation under four different discount rates (-2%, 2%, 4% and 6% per annum) which is one of the reasons for the wide range of estimates.[7] The

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inclusion of a negative discount rate is unusual, and based on a piece of work by Blignaut and Aronson (2008) that argues for negative discount rates to reflect the increasing scarcity of environmental resources as they degrade.

3.3.3. Value for whom?

The manner in which people value risk, leisure time, heritage and aesthetic beauty is not only innately subjective, but it is influenced by socio-economic status and ecosystem values accruing to one community, which may involve losses to another group. For example, a functional coastal storm surge buffer may protect some people from the storm impact, but may involve foregone real estate opportunities for others. In a country such as South Africa that is defined by socio-economic inequality and race-based class divisions, it is to be expected that finding a consensus value for ecosystem goods and services will be difficult (Colenbrander et al., 2014).

For this reason, ecosystem service valuations need to be explicit about whose values are being applied to the ecosystem goods and services. Where necessary, valuations must identify the 'winners and losers' associated with the recognition of a particular valuation (World Bank, 2004) and weight their values relative to income (Jacobs, 1991).

The De Wit et al. (2009) study of Cape Town reflected value as perceived by the following constituents:

- Tourists (international, national, local);
- Recreation groups (beach bathers, sailors, surfers, rowers, people who picnic and braai, walkers, cyclists, hikers, sports groups);
- Harvest groups (fishers, wild plant harvesters, urban agriculturalists, fuel-wood gatherers);
- Informational and cultural groups (education, scientific research, religious experience, book writers);
- Industry groups (film, advertising and events industry, shipping, tourism, manufacturing, crafts); and
- Residential groups.

Interestingly, the study focuses primarily on private sector stakeholders and local government was not considered as a key stakeholder in calculating values. A valuation through the lens of the CoCT might have focused on the narrower flow of rates and levies back into the CoCT's fiscus, as opposed to the local economy. The omission of the CoCT as a stakeholder is unusual and highlights the important need for studies of this nature to articulate whether they are conducting the valuation on behalf of public or private sector entities. This will depend on whether the required investment or action is sought from government or the private sector, and it will dictate whether the methodology adopts a financial or an economic focus. The two are significantly different – a financial study has a narrow focus on money spent and acquired, whereas an economic focus makes use of 'opportunity costs' and the intrinsic value of goods and services to all of society whether or not these are reflected in monetary transactions. The respective values of public and private sector entities are often confused or conflated in what construes a common valuation error. The economic value and broad investment case shown by the Cape Town study certainly does not automatically create an investment case for specific stakeholders when they focus on their own finances or narrow self-interest.

3.4. Valuation findings

Given the use of different scenarios, discount rates that ranged from -2% to 6%, and the variation in valuation methodologies, a wide range of values was calculated for Cape Town study. The study found that "when conservatively adjusted for other ES", Cape Town's environmental assets could be valued at R43-R82 billion and that these assets provided a benefit of between R2-R6 billion per annum (2009 prices) (De Witt et al., 2009: viii). The study disaggregated the value of ecosystem goods and services in a number of ways showing, for example, that natural hazard regulation provided a total benefit of R1.5-R4 billion per annum for the tourism and

7. Discount rates reflect individual and corporate perspectives of the "time value of money" and the common human trait prioritising the current period over the future period. Typically, higher discount rates are used when the future value of something is less certain. When and individual is ambivalent about accepting R100 today or R110 in a year's time, then it is assumed that they are discounting the value of that money by 10%. As such, discount rates are inherently subjective and also influenced by wealth status and individual risk aversion.

Photographs by Clive Hassal

recreation sector, the film industry, and for people living in and visiting the city.

The study further calculated that for every R1 from the fiscus that was invested in the rehabilitation of Cape Town's ecosystem goods and services, it would generate R8.30 worth of gross domestic product (GDP) for the local economy. This equates to between 20% and 100% more economic value than R1 invested in the general economy. This finding implies that a fiscal reallocation to support the management of ecosystem goods and services would be good for economic growth in general.

3.5. So what?

Knowing that the natural environment is valuable is of little use if it does not lead to real investments in conserving it (or the forfeiting of income to protect this value). The reaction to the De Wit et al. (2009) study was, with the benefit of hindsight, similar to the reaction received by the Costanza valuation more than a decade earlier. There was interest in the numbers and the results featured in public addresses, strategy document preambles and academic publications. However, most of the enthusiasm for the report emanated from people that were not responsible for investments and did not need convincing in the sense that they already appreciated the value of ecosystem goods and services.

For example, it is clear from interviews that the Director of Budgets in the CoCT has read and understood the report. However, as with these types of valuations elsewhere in the world, this did not lead to a significant economic reform or reallocation of budgets, and it is necessary to ask why this was the case. The De Wit et al. (2009) study did try to manage expectations and answer this question. The report notes that "good data and evidence will have little impact or influence over decision-makers unless packaged carefully and communicated effectively" (De Wit et al., 2009: xiv). It posits further that "choices are not made based on perfectly rational, weighted indices, but rather driven by certain heuristic rules influenced by the positions of party leaders, by interest groups or by a focus on single-focus issues" (De Wit et al., 2009: 242). These observations represent an important consideration; one that requires further disaggregation and analysis if valuations are to be useful in influencing investment.

3.6. Theoretical barriers

3.6.1. Public goods and attribution problems

Who owns the value of ecosystem goods and services and who should be responsible for paying to protect the loss of value? Most environmental assets are public goods: they are consumed by (or deliver benefits to) many people at the same time, and it is prohibitively expensive to exclude people from their benefit. This presents the key challenge of who should take responsibility for protecting their value when they are being degraded or are becoming increasingly scarce (such as in the case of potable water), or when the good (or its protection) requires a significant investment (such as wetland rehabilitation). Given that the benefits of public goods are shared across society and have historically been considered free, no single individual or company is incentivised to take the initiative and invest in them. On the contrary, individuals hold back their investment and instead adopt a free-rider attitude, waiting for someone else to invest on their behalf or over-consuming the resource before somebody else depletes it – the 'Tragedy of the Commons' scenario described by Hardin (1968). It is for this reason that public goods are typically the responsibility of governments, who levy taxes and take responsibility for these goods on behalf of all people. However, governments themselves are not always adequately resourced and do not face the full, or immediate, consequences of underinvestment

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> **"Principles of economics are structured around the normative value – the way things ought to be – and the value that economists ascribe to things on behalf of a generic understanding of society. The latter is often far removed from the financial reality of the constituents of that society."**

in ecosystems goods and services. For this reason, governments often ration their investment in these goods in favour of concerns that are more visible to the electorate.

3.6.2. No 'collective choice' model for the right amount of investment

Effective stewardship of public goods requires a collective choice model that is predicated on individual needs and preferences (Ostrom, 1998). Individuals, however, are both consumers and citizens, and environmental decisions span both of these domains. To arrive at a collectively supported process of how stewardship should proceed requires both an exposition of the risk and a shared understanding of its impacts, including options for addressing these. Not only is the necessary information difficult to come by (and we know that degradation has negative consequences) there is also an innate uncertainty over the impact and timing of these consequences (Cartwright et al., 2013), and consensus views are not forthcoming where cultural and socio-economic differences make for disparate preferences. As a result, it is very difficult to define the right response to subjective environmental problems in terms of the budget that should be invested or the correct level of foregone economic growth.

3.6.3. Finance versus economics

Principles of economics are structured around the normative value – the way things ought to be – and the value that economists ascribe to things on behalf of a generic understanding of society. The latter is often far removed from the financial reality of the constituents of that society. An economic valuation of ecosystem goods and services is relatively easy, but the outcomes do not necessarily lead companies or governments to reallocate their money. Certainly for governments, the ability to make radical budget reallocations or to invest large amounts of money in new goods and services is not traditionally a feature of their financial management process.

As the Director of Budgets in the CoCT points out, the total allocations for environmental protection in the city were formally recorded at R166.6 million in 2009/2010, but these departments only generated R17.7 million in recorded revenue. This makes it difficult to invest the fiscus in environmental protection without disturbing the City's financial stability. This fiscal stability represents an immediate priority that is unrelated to, and even at odds with, the flow of benefits referenced in the De Wit et al. (2009) study, as most of these benefits do not accrue to the CoCT's fiscus in the short-term.

3.6.4. The 'part-whole' problem

The valuations of ecosystem goods and services rely on subjective proxy pricing methods and are often considered less legitimate than the values (or costs) ascribed to an entity by conventional markets. Investors find it difficult to observe and comprehend the multiple benefits that arise from the environment, particularly when those benefits accrue at a future date, and are not observable or involve avoided damage. This is often the case for ecosystem goods and services. Vatn and Bromley (1994) refer to this as 'functional transparency' – that the precise contribution of a functional element in the ecosystem is unknown and difficult to value until it ceases to function.

3.6.5. Incommensurability

A constant feature of field experience involving environmental valuation is the discrepancy between respondents' indicated willingness to pay for the protection of the environment and actual payments when these are required – even when the results are adjusted for the various survey biases (Jacobs, 1991). Vatn and Bromley (1994) and Monbiot (2010) independently attribute this inconsistency to the incongruences that arise when people are required to make a trade-off involving money and a moral principle. In their minds people tend to ascribe very high values to moral principles (including the value of nature), but do not necessarily equate this value to a personal financial payment.

For Monbiot (2010), the conflation of moral principle and monetary value represents a source of a profound misrepresentation in many environmental valuations. In commenting on the work of TEEB in 2010, Monbiot (2010) pointed to the difficulties that arise from comparing economic metrics with intrinsic values. The primary concern here arose from the principle that "as soon as something is measurable it becomes negotiable." This negotiation is based on subjective understanding of the natural world, and the protection of the natural world can become a victim of different agendas – people can pick and choose which components they think should be kept and those that can be disposed of. Monbiot (2010) posits further "that, in the weird world of environmental economics, [it] isn't hard: ask the right statistician and he'll give you whichever number you want. This approach reduces the biosphere to a subsidiary of the economy. In reality it's the other way round: the economy, like all other human affairs, hangs from the world's living systems" (Monbiot, 2010).

3.6.6. Practical barriers

Theoretical and conceptual rationales underpin the challenges experienced in Cape Town (and elsewhere) in converting ecosystem goods and services into economic reform, and increased investment in ecological assets. It is not, however, how local officials articulate the difficulty they experienced in applying the information in the De Wit et al. (2009) report to their day-to-day actions. The reasons provided were more prosaic, in spite of having their origins in the theoretical dilemmas.

3.6.7. Shared mandates

At the local level, activities are performed by teams operating within line departments, each with its own budget allocation. Ecosystem goods and services, however, transcend line department functions and legislative boundaries. Not only would a programme of investment in these assets require a level of combined government that does not yet exist in South Africa, but departments tend to shift responsibility for the difficult decisions and budget commitments to other departments or other spheres of government, while focussing on the more technical, less systemic problems in which they have a chance of demonstrating success.

Photograph by Christina Culwick

3.6.8. Meaninglessly large numbers

The economic value estimates produced by the De Wit et al. (2009) study are large figures. The upper-end value of ecological assets in Cape Town was more than double the annual budget allocation made by the CoCT (in 2009). In this sense, the number is overwhelming and it does not lend itself to a budget response that could do justice to the economic value, and instead leads to paralysis.

3.6.9. Budget applications

Local finance officials and private sector investors lament that they are not presented with 'shovel-ready'[8] projects and budget requests in a way that would allow them to respond with appropriate resource allocations. The claim is that officials in the ERMD and lobbyists in civil society operate in campaign mode without ever complying with the procedures for presenting a budget request, in the required format, at the right time, and following the standard budget approval processes. The implicit challenge to proponents of ecological valuation is to convert their understanding of the value reported in their studies into well-managed, budget-worthy projects with the associated budget requests for reasonable amounts of money. In the words of one senior official at CoCT, "At local government level, if you are not in the budget you do not really exist". Local governments are defined by their budget allocations and it is incumbent on proponents of ecological assets to submit appropriately packaged budget requests that allow officials to recognise and act on the values contained in valuations of ecosystem goods and services.

3.6.10. Municipal Finance Management Act barriers

It is sometimes claimed that South Africa's Municipal Finance Management Act (MFMA) (Act No. 56 of 2003), with its emphasis on the three-year budget cycle and cost-effective procurement, provides a barrier to long-term environmental investment. A detailed study by National Treasury's Technical Assistance Unit (TAU, 2013) found that the Act's technical content had been used by finance officials to veto climate change adaptation investments where these officials harboured reservations about the programme of action or the nature of the budget request. In this way the MFMA had occasionally provided a useful obfuscation instrument. The report was clear, however, that the MFMA was not designed with this in mind and did not constitute an absolute barrier to the required investments (a conclusion reached by De Visser (2012)). The key impediment for many environmental activists was not the MFMA itself, but familiarity and skill in applying the Act.

3.6.11. Low priority

For many decision-makers the environment remains a luxury good, deserving of attention and budget resources only once more pressing needs such as housing and basic services have been satisfied, or to prevent and respond to natural catastrophes. This is a view that fails to acknowledge the important linkages between human wellbeing, development and the health of the natural environment (Cooke et al., 2010), but which remains prevalent due to the systematic discounting of environmental value and the perceived lags between environmental investments and human benefit. In this sense, valuations of ecosystem goods and services are considered interesting but not materially important to finance and investment managers.

3.6.12. Unfamiliarity and incomparability

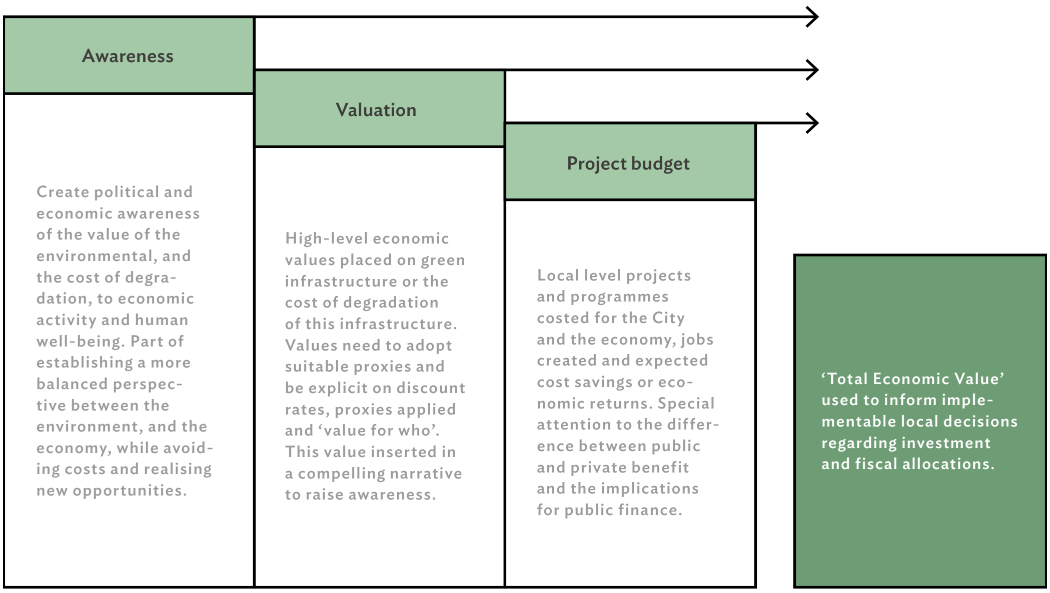
Although case studies have begun to emerge, the notion that a wetland, for example, might be relied upon to provide flood retention or water purification is unfamiliar to many city officials. Changing this perception will take time, especially given the historical dominance of engineered services in the decision-making and financial landscape. In the interim, many officials feel that the types of values produced by studies such as De Wit et al. (2009) are incomparable with the economic returns calculated for a shopping mall or a water purification plant.

8. Not all projects involved earth moving, construction or a shovel, but this term became a metaphor for projects that had leadership support and were able to be implemented (and spend their allocated budget) within the financial year.

3.7. Green economy and environmental fiscal reform project

Following the experience with the valuation of ecosystem goods and services in Cape Town, officials in ERMD realised that while the process was important in raising awareness, subsequent steps were required to give the ascribed values traction in fiscal management and local economic decisions. Many of the steps that emerged from the valuation of ecosystems in Cape Town formed part of what has become the City's green economy programme. Figure 3.1 presents an overview of steps taken to achieve and implement the notion of the green economy programme based on findings related to the valuation of ES.

Figure 3.1: The role of valuations of ecological assets in a broader process of valuing the natural environment in local economic decisions and securing investment



CoCT's green economy was construed as a means by which economic decision-making could guide the city in developing an economy that exhibits the attributes identified by the United Nations Environmental Programme (UNEP) (UNEP, 2011). This refers to a low carbon and resource efficient city that is socially inclusive (Attwell, 2013). The ERMD deliberately did not set about writing a high-level strategy or policy document,[9] but instead sought to learn from the valuation exercise and focus on projects and budget allocations that could be showcased as emblematic of the type of green economy that Cape Town wished to nurture. To this end, the CoCT produced a green economy concept note and established criteria through which to identify and prioritise green economy projects. These criteria (listed below) require projects to:

9. The Western Cape has an encompassing Green Economy Strategy Framework that was released in 2013 (Western Cape Government, 2013).

- Demonstrate a clear rationale for local government intervention in the sense that they were within local government's mandate and involved in some form of market failure – as a result of collective actions, problems, or public good attributes;
- Involve a cost saving or a shift towards fiscal efficiency in the sense that they delivered a better service at the same cost;
- Involve job creation or labour absorption opportunities of the type that unemployed people in Cape Town might be able to access (i.e. local, low-skilled and linked to a sense of place). The emphasis on job creation was based on the notion of work as the most reliable pathway out of poverty, and the recognition that the capital intensity of South Africa's current economy is inappropriate given the levels of unemployment. In addition to job creation, project proposals were evaluated in terms of the extent to which they reflected a fair, and more equitable, distribution of costs and benefits;
- Support growth or risk reduction;
- Constitute a reasonable demonstration in the sense that they would succeed or fail based on their intrinsic merits, and not due to political or other reasons. Thus mega-projects such as the Integrated Rapid Transport System (which might conventionally have been expected to be included under the green economy) were excluded from the initial phase; and
- Be reasonable in terms of their cost and in terms of the technical complexity required for implementation.

Based on these criteria, officials from a range of line departments submitted 68 project proposals. The criteria were applied to these projects to prioritise and select four projects with the assistance of senior CoCT officials. The four projects were closely aligned to the notion of green infrastructure (GI) and include:

- Dune rehabilitation to prevent wind-blown sand damage and storm surge flooding;
- Extension of waste-picking in informal settlements so as to reduce the cost of complying with the CoCT's recycling by-law;
- Composting toilet project to test the community's acceptance of the technology, demonstrate its potential and gather intelligence on the respective options; and
- Clarification of the biodiversity offset process to ensure consistency across offsets, alignment with the biodiversity network research and a return of offset revenues to the fiscus.

The selected projects budget notes were compiled and requested a total of R12.8 million. These budget outlined the direct costs and benefits to the CoCT, the broader economic implications, job creation potential, alignment with CoCT's Integrated Development Plan (IDP) and a breakdown of capital and operational expenditure required over the three-year Medium-Term Expenditure Framework. As it transpired, R100 million was allocated to the projects via the CoCT's Expanded Public Works Programme – a programme that has no expenditure of its own but which collaborates with line departments in labour intensive activities.

In this way the 'meaninglessly large' figures produced by the De Wit et al. (2009) study were given meaning in more manageable, and budget-worthy, requests that could be addressed within the three-year expenditure framework. When focussing on a specific project it proved easy to move from the abstract to the practical, and to be more specific about cost savings, expenditure requirements, relevant legislation (including by-laws), job creation, and roles and responsibilities. The overarching rationale is in many ways linked to the De Wit et al. (2009) report, but the focus of activities is much more applied and more closely aligned to CoCT's operations.

Work has commenced on some of the projects. Predictably, the requirement to spend budget within constrained periods, whilst simultaneously managing

"... the CoCT produced a green economy concept note and established criteria through which to identify and prioritise green economy projects"

labour forces (employed variably by the CoCT and through contractors) and delivering services in a novel manner, has presented new challenges. These, however, are considered part of the transition towards a low carbon, resource efficient and socially inclusive green economy (Attwell, 2013).

Once the valuation of ecosystem goods and services was seen as part of a set of instruments in the green economy, the focus shifted towards complementarity with existing cityscale planning instruments, and a concerted effort to combine various approaches. Complementary strategies aimed at attracting investment in ecosystem goods and services have been deployed in tandem with these valuations. An overview of these is presented below.

3.7.1. Demonstrating cost of employment

The costs of creating suitable[10] employment through investments in ecosystem goods and services warrants further attention in South Africa. The South African National Biodiversity Institute (SANBI) claims to have created 486 000 jobs in environmental rehabilitation programmes since 1995. Typically, the cost for government through creating employment in GI is less than that in conventional industrial sectors and the type of employment created is more suitable. This is in terms of requiring low skill levels, being proximal to places of residence and nurturing a sense of place and belonging. This approach to employment creation goes beyond the addition of new 'green' sectors with the potential to offer employment (Maia et al., 2011), and instead seeks to redress the capital-labour structure of the existing economy in a manner that supports labour absorption.

3.7.2. Linking explicitly to the built infrastructure rollout and Green Municipal Infrastructure Grant

South Africa is in the midst of a renewed attempt to build new infrastructure and to maintain and refurbish existing infrastructure. The World Bank put South Africa's infrastructure backlog at R500 billion per annum for ten years, which is just under half the required expenditure needed to maintain and restore existing infrastructure (World Bank, 2010). As a first step, new infrastructure needs to be built in a manner that complements, and does not destroy the services already being provided by the natural environment. Complementarity can improve the functioning of built infrastructure and massively reduce its cost. It is further necessary to recognise that in some instances the natural environment already provides important municipal services including water purification, energy, flood buffering and stormwater drainage, and business and recreation opportunities. In some instances the value of these services is far greater than those provided by the built environment. Furthermore, the obvious difficulty that South Africa has experienced in maintaining its built infrastructure could be circumvented by relying on less technical and easier to maintain ecological infrastructure. Documenting the municipal services provided by the natural environment can further make the case for these services to be provided more cost-effectively at the same or at a higher level, creating more work opportunities than is the case for the built environment. In recognition of this potential, South African municipalities have already begun making the case for spending portions of their Municipal Infrastructure Grant (MIG) on restoring and maintaining ecosystem goods and services.

3.7.3. Holding private sector investment accountable to legislation

South Africa's World Wildlife Fund (WWF) is currently involved in a project aimed at enhancing private sector investment in ecological infrastructure. The approach adopted by WWF recognises the barriers to this investment (including public goods, subjective values, low returns on investment and long timeframes) and instead seeks to ensure that loan finance and insurance policies are not extended to operations that breach existing environmental legislation. These include respect for wetlands, riparian buffer zones, water contamination, and control of alien invasive species. In this way financial institutions not wanting to be complicit in breaching legislation limit their investments to activities that recognise and protect ecological infrastructure.

10. Suitable in the South African context involves low-skilled, local and linked to local value addition.

Photograph by Christina Culwick

3.7.4. Increasing the evidence base

Ongoing research is required to demonstrate the value of ecosystem goods and services. In the wake of the 2007 storm surge along the KwaZulu-Natal coast, it became clear that those areas located behind functional coastal habitats required much less restoration investment than those where development had disturbed coastal dynamics and changed natural buffers. Similar evidence is available from flooded areas adjacent to rivers, infrastructure damaged by landslides and water resources contaminated by sewerage. Case studies that highlight the cost savings afforded by functional ecosystems make a powerful financial case for investment in their preservation, as do examples of the livelihood and economic opportunities created by healthy and diverse environments.

3.7.5. Precautionary principle

The dramatic loss of economic and social options that result from degradation events and environmental disasters requires an application of the 'precautionary principle'. This, however, has proven a very difficult concept to insert into markets as it is typically construed as a form of inefficiency and even market failure. It has proven even more difficult to insert into development planning, especially where local politicians feel under pressure to create development opportunities and delays to new housing, infrastructure or business opportunities as a result of environmental concern are viewed as 'anti-developmental' or 'green-tape'. In practice, the precautionary principle is most effective when linked to the potential culpability of negligence by a specific individual or department. Where a department or developer, for example, knows they will be held accountable for the development of a riparian property in the event of a flood, they are much more inclined to be cautious in approving the development.

3.7.6. Development charges

All 'greenfield' developments pay development charges as a contribution to the supply of bulk infrastructure in recognition of the impact and cost of their construction footprint on the environment. In general, development charges have been poorly administered and as such have been construed as part of red-tape - and occasionally green-tape (Attwell, 2013). As a principle, however, development charges should relate to the externality costs that a particular development imposes on society. Seen through this lens, development charges could be used as source of revenue for the maintenance of ecosystem goods and services, especially once the value of those services has been established.

3.7.7. Biodiversity offsets

As with development charges, biodiversity offsets can be used to secure investment in patent habitats in exchange for forfeiting those habitats that have become terminally compromised by poor spatial planning and development decisions in the past. The efficacy of biodiversity and the impact of invested offset revenue can be greatly enhanced where the value of ecosystem goods and services has been established *ex ante*.

3.7.8. Carbon market

Two of Cape Town's green economy projects associated with waste handling have secured revenue from the private sector through South Africa's voluntary carbon market registry, Credible Carbon. The ability to crowd-in private sector funding on the back of fiscal allocations to the green economy not only yields a virtuous investment cycle, but encourages both private and public sectors to allocate further resources.

3.8. Conclusion

With the benefit of hindsight, it is possible to draw some inference from the ERMD's experiences with valuing ecosystem goods and services in Cape Town. It seems reasonably clear, both from international literature and Cape Town's experience that GI embodies characteristics and values that, even when represented as a monetary value (based on the aggregation of individual's values and proxy pricing methodologies), are difficult to impute into budget decisions or economic behaviour in the same manner as more conventional values or prices.

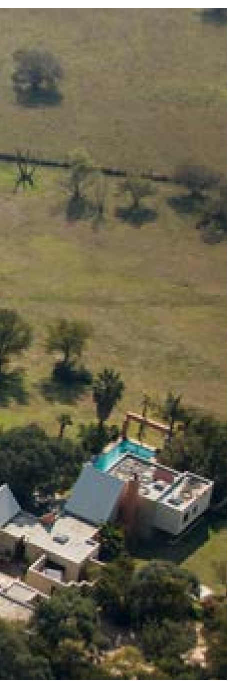
This does not mean that valuations of ecological infrastructure are not necessary or useful for planning and decision-making. On the contrary, the Cape Town study was important in raising awareness with regards to environmental value and the role that the environment plays in supporting Cape Town's society and economy. There remains a strong case for valuations of GI as a means of highlighting the inventory value of this infrastructure type and for drawing attention to the changing inventory value over time – as well as the consequences (positive and negative) of these changes. For valuations to contribute to fiscal reform, they require that the valuation process be seen as only one part of the evidence base, and also be supported by localised requests for budget and investment.

The actual valuation methodology selected also needs to be credible. In this sense it needs to draw on one of the many internationally recognised

Photograph by Clive Hassal

frameworks and contingency pricing mechanisms. Objectives need to be explicit about whose values are being imputed and the discount rates that are applied. The methodology also needs to be applied consistently over time. The outcome of the valuation (in the form of an economic figure) is, however, less critical than the narrative around the number. An appropriate narrative includes whose values have been captured, who stands to benefit and lose from a greater recognition of ecosystem value, and how recognising this value might lead to economic or development opportunities.

This type of information is much easier to provide at the local level and in the context of a specific project. Certainly the ERMD in CoCT only managed to secure additional budget when they used the principles captured by the De Wit et al. (2009) study to present the investment case (including costs and benefits to the CoCT) of specific local shovel-ready programmes and projects. The onus on environmentalists then is to recognise the barriers to investment that are based on high-level valuations of GI, and to make a shift beyond the use of these valuations as a stand-alone tool for lobbying. Instead, valuations are most effective when used to highlight existing services and additional opportunities for job creation and cost savings for local governments, and cost savings and risk reduction for private investors. Once the investment case involves more than direct expenditure and financial returns, as is always the case when dealing with GI, it invariably becomes subjective. For this reason, valuations of ecosystem goods and services are likely to be most effective in attracting investment when they are produced collaboratively with the finance department or investors that are most likely to make an investment. For local government officials in South Africa, an obvious complement to GI valuations involves submitting budget applications for GI projects that could be supported by the MIG.



4. Valuing green assets in Gauteng - not the 'valuation' thereof

*WRITTEN BY MYLES MANDER**

4.1. Introduction

Although valuation is a necessary component for understanding the value of ecosystem services (ES), it is insufficient in itself to ensure that green infrastructure (GI) is incorporated into the municipal decision-making process. A distinction is made here between the valuation of and valuing green assets. Valuation implies providing a monetary value for a particular commodity or asset. Valuing green assets, however, is much broader than this and can be seen as a process that focuses on developing the appreciation of the role and value of GI in municipal service delivery. The distinction between value and valuation can be considered through the example of education. The valuation of education in monetary terms would provide a financial assessment of the education system, and the financial cost and benefit of education. Whereas developing an appreciation for the value of education would include recognising the freedom, opportunities, knowledge and empowerment it provides individuals and society.

This chapter posits that it is necessary to engage in a process of developing an appreciation of the value of GI, rather than simply placing a price tag on it. To this end, this chapter presents a series of case study examples that together reflect on the value of GI and the ES they provide.

International evidence suggests that although financial valuation is critical for incorporating green assets into financial systems and municipal accounting, it has been unsuccessful in transforming existing governance structures. Global market and governance systems have failed in effectively managing the functioning of ecosystems and the services they provide. This can be attributed to the limited understanding of the value of natural systems, and the existing governance systems cannot adequately incorporate them into policy and planning. Consider public services such as education, policing and military deterrents. It has taken decades for governance and market systems to supply these services. These systems, however, have not yet evolved to adequately account for the supply of ES for public consumption. The uptake of ES into governance and market systems is challenging due to three main factors. Firstly, these services are already owned by hundreds of private and public entities around the world. Secondly, they are consumed by almost everyone on earth; and thirdly, most of the suppliers and users of ES are not aware of the services that are produced and consumed, the inter-relationships that exist between services, and the human dependence on these services.

4.2. eThekwini urban management projects

4.2.1. Open space planning

In the late 1990s, eThekwini Municipality (formally the City of Durban) included the concept of ES in their municipal programme as a way to reimagine the role of open space. Part of this programme included a participatory mapping exercise that investigated untransformed space that falls within the municipal boundary. The process - albeit only involving the environment branch of the municipality - had a strong spatial focus and used participatory methods. The process involved the municipal staff in systematically identifying and mapping the green assets, identifying the services supplied by these assets, and defining the role of the services at the local and regional levels (Markewicz et al., 1999).

Following this mapping exercise, the indicative monetary value of green assets in eThekwini was estimated by applying the average value per hectare. These values were calculated using data produced by the Costanza et al. (1997) paper. The valuation exercise concluded that the services provided by green assets saved the city approximately

* FutureWorks

one-fifth of the annual municipal budget, which was largely through avoided replacement costs. The framework was driven by municipal champions and was adopted by council despite serious opposition to the environmental conservation programme at the time.

The participatory process that was used to map and value green assets in the city built an understanding and capacity within the environment branch of the municipality to engage with the concept of ES. This included using the concept in their daily engagements with other departments. The concept was also used to garner support for effective land use management in the city and became embedded in a range of municipal plans. The urban planners in the city were particularly comfortable with the idea of ES and were early adopters of the value of ES within the municipality. The language related to ES slowly started to develop within the municipality despite the opposition to the valuation of ES that had been undertaken by the City. The indicative values were not considered to be credible by many staff as they were too high and these services had been considered free in the past.

Reflecting on this process, the uptake of the language and metrics of ES in the planning and services departments in eThekwini can be attributed to the focus on service delivery, instead of biodiversity conservation. This emphasis made arguing against environmental management investments more difficult. The process of valuing ES highlighted the magnitude of the associated services delivered to the City, and despite being considered 'free', the services did not have zero value.

"The urban planners in the city were particularly comfortable with the idea of ES and were early adopters of the value of ES within the municipality."

4.2.2. Climate change adaptation

Following the ES valuation exercise, the city conducted a cost-benefit analysis to determine how to prioritise the implementation of climate change adaptation strategies. Unlike the open space planning process, this process presented challenges for prioritising strategies and this is linked to the monetary valuation methods used in the valuation of green assets. The outcome of the monetary valuation process was inappropriate for ranking adaptation priorities because it did not consider the number, the socio-economic context, or the people who would benefit from the various adaptation strategies.

This challenge can be illustrated by a hypothetical example of two proposals pertaining to the rehabilitation of wetlands with the aim of reducing flood risk. The first proposal would reduce flood risk for 100 households that lie adjacent to the Umgeni River. Each house along the river is worth R30 000, or all together, a total of R3 million. The second proposal focused on reducing the flood risk for ten households each worth R3 million, or combined a total of R30 million. The benefit of the second proposal, in monetary terms, would far exceed the first proposal due to the individual property value. Thus using monetary values as the only prioritisation criteria has its limitations as only houses with a higher value would be prioritised. This, however, is not the 'correct' approach as all these homes hold value for the residents, and thus should not be based on monetary terms.

To overcome the challenges associated with monetary valuation methods as a means of prioritising options, a human benefit index was developed. This approach compared adaptation costs (in Rand) with further adaptation benefits (Klugman et al., 2011). The human benefit index considers the number of people and the degree of impact experienced under a particular scenario. In other words, it identifies the number of lives the project would save, the number of people whose wellbeing would be significantly improved and those who would experience a slight improvement (Cartwright et al., 2013). Using a human benefit index (or a genuine progress indicator (Costanza et al., 2014)) is increasingly gaining acceptance as concepts such as household and human wellbeing are prioritised, and have political traction and support.

4.2.3. Exploring catchment thresholds and desired catchment service levels

In 2012, eThekwini explored a new valuation approach that included the use of ES as indicators in assessing catchment thresholds, and whether one could use desired ecosystem service levels to guide catchment management (Mander et al., 2012). Participatory systems modelling was used to guide a process that identified the relative services levels supplied per habitat type (see Figure 4.1)

The participatory systems model is based on social-ecological systems theory, which assumes that green assets are not considered as independent ecological entities. The systems model uses ES as the common currency for dialogue between society, engineers, developers and scientists. The process uses a series of structured discussions, providing the space for participants to interact in a synergistic manner, bringing to light expert knowledge and generating new understandings of the system. These discussions provide the basis for the model inputs, and include local experiences, expert wisdom and basic available data (such as habitat areas, habitat condition and connectivity, and population numbers). These inputs are used to develop a series of relative scores, which drive the model. A critical element of the process is to develop consensus on the allocated scores, as this builds credibility in terms of the process outcomes.

The various components of the model include the ecological assets and the ES that they supply, and the demand for services, including the number of people and their level of demand for those services (and human benefit indices). The model then assesses a range of future scenarios by changing the ecological functionality variables or demand variables in response to various future scenarios. These future scenarios include the predicted changes in ES supply levels or service demand. These can be interpreted in the context of the possible urban and rural development, and can be used to inform land use or management decision-making processes.

The process of developing the model inputs and reaching consensus within the stakeholder group is as important as the model outcomes. The development of a common conceptual model by the group, in addition to providing a systematic structured discussion, is in itself a critical outcome of the process as it builds a basis for co-generating future management options. The model serves to document or record the outcomes of the discussion and the consensus of the group.

In the eThekwini example, the demand for services was mapped using the Eskom 2009 household data, which clearly showed how many people used which services and where (Figure 4.2). Changes in ES in different future catchment scenarios were then assessed. Various scenarios were developed by the workshop team, exploring a range of possible futures, including maximising management of built landscapes (including greening), maximum management of green assets, and a utopian best case scenario. By changing the size, condition and connectivity of the land cover types in each scenario, the model assessed how past, current and future service levels compare to the desired service levels.

Several municipal departments participated in this

“The participatory systems model is based on social-ecological systems theory, which assumes that green assets are not considered as independent ecological entities. The systems model uses ES as the common currency for dialogue between society, engineers, developers and scientists.”

Figure 4.1: The range and relative supply of ecosystem services per hectare for each land cover type in the Umbilo catchment based on current condition and connectivity

BIOPHYSICAL CATCHMENTS ASSESMENT

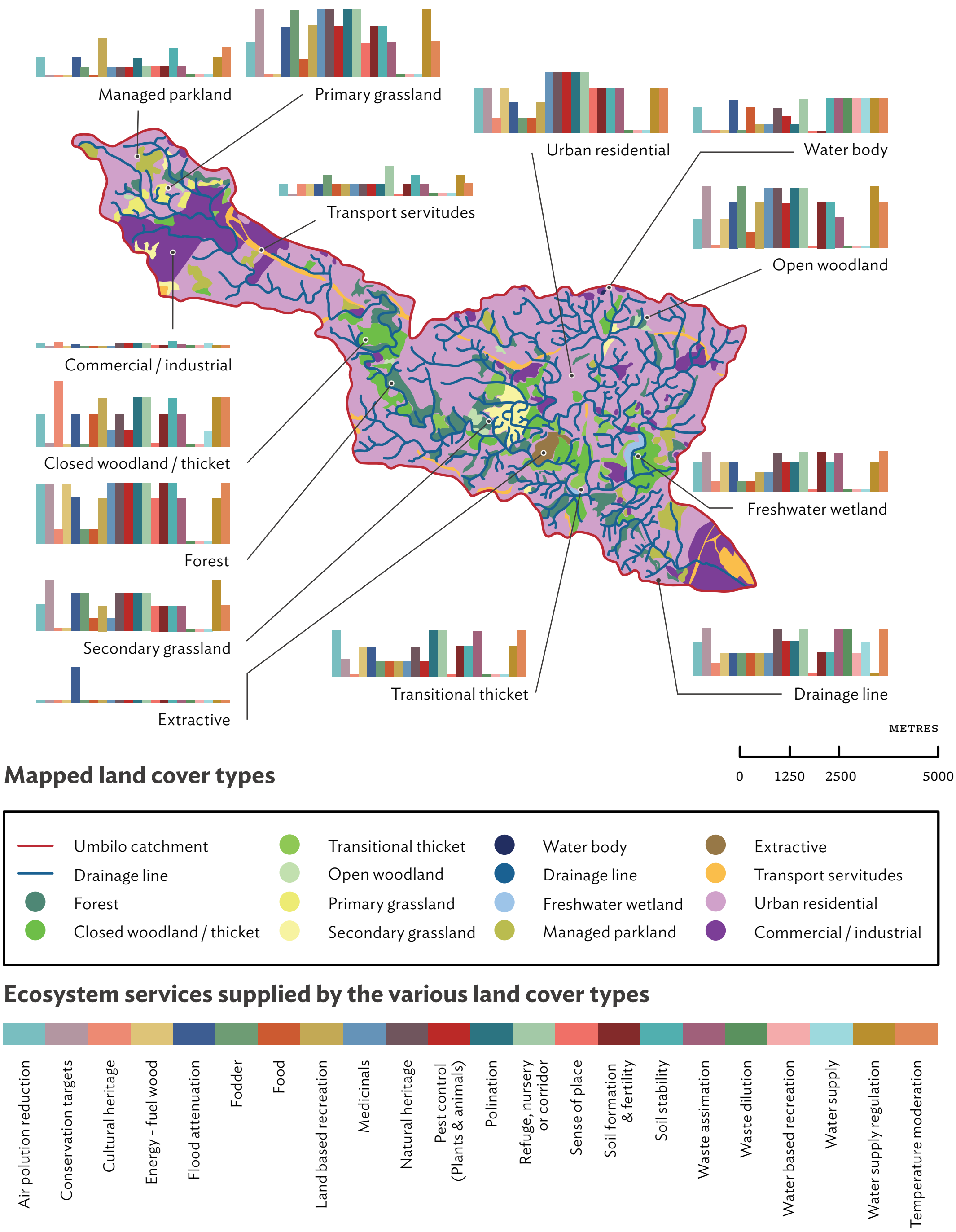
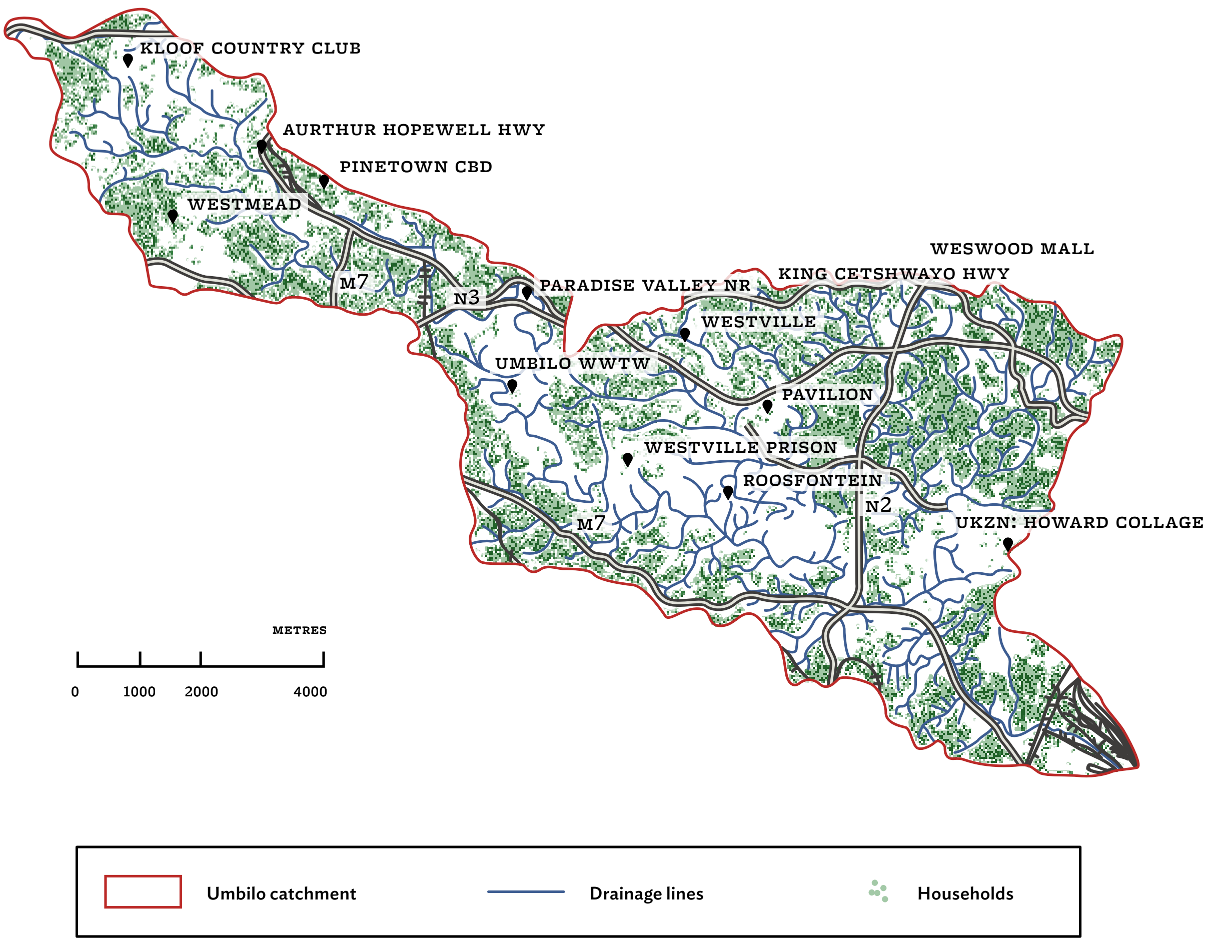


Figure 4.2: Map showing the location and intensity of demand for ecosystem services in the Umbilo catchment

BIOPHYSICAL CATCHMENTS ASSESMENT



process, including wastewater, water, stormwater, housing and transport. The desired service levels and the various scenarios were developed collectively by all participants. In addition, the participants were asked to consider whether the ES currently supplied were adequate or not. The answers to these questions then allowed the team to model possible solutions for where the services were not adequate. The process showed where ecological restoration and greening should focus to improve selected services levels, and where natural areas were unable to cope with demand or usage levels. Furthermore, it identified where engineered actions were required to restore ecological processes, such as poorly performing sewage systems.

This exercise highlighted the possibility of using modelling techniques to identify desired and undesired services levels, and that management priorities could be identified using indicative values, instead of monetary values. Priorities were selected based on a human benefit index associated with ES supplied in each management scenario. This process was not considered threatening for any department involved because of the focus on scenarios and modelling solutions, without apportioning blame or responsibility.

4.3. Knysna ecosystem services analysis

In 2013 an ES supply and demand analysis was undertaken in collaboration with South African National Parks (SANParks), Knysna Municipality and Eden District Municipality (Mander et al., 2013). This analysis involved a similar participatory modelling process as was used in eThekwini (described in Section 4.2), and included staff from the participating institutions over the course of four days.

The participatory systems modelling process was employed to conduct an ES supply and demand assessment of the Knysna catchment. In this case, a set of future scenarios were developed incorporating different levels of environment management and population growth. These scenarios were generated by projecting land transformation and population growth trends into the future, through exploring potential large-scale developments, such as a dam development, and by exploring a green development future (see Figure 4.3). A service risk and opportunities assessment was undertaken as part of the modelling process. This process enabled the group of stakeholders to populate the model using their local knowledge. The participants considered the outcomes of the scenarios modelling, and broadly accepted the future scenarios as credible because of their contribution to the model inputs. The participants agreed that the future scenarios that showed declining services levels were undesirable (scenarios 2, 3 and 4 in Figure 4.3), and that the green growth scenario (scenario 1 in Figure 4.3) was the desired future scenario. The consensus building process established an important basis for future collaborative work between the participants, particularly in light of the shared vision for the future. No monetary valuation of services was undertaken in this process. How this process will lead to municipal planning actions and implementation is yet to be seen.

4.4. Broader environmental management

4.4.1. Maloti-Drakensberg and Baviaanskloof-Tsitsikamma watersheds

Between 2006 and 2010 two intensive research processes were undertaken to evaluate the potential of watershed management in enhancing regional water security in the Maloti-Drakensberg and Baviaanskloof - Tsitsikamma watershed systems (see Blignaut et al., 2010; Mander et al., 2010). Research teams included national experts who conducted extensive eco-hydrological modelling. In both watershed systems the work concluded that watershed management was a cost-effective means of enhancing water yields and base flow, and reducing damaging storm flow and sediment yields. It was estimated that watershed management could deliver water at 25% of the cost of building dams. However, yields would be relatively small and assurance of supply was modest due to possible climatic variability, including droughts.

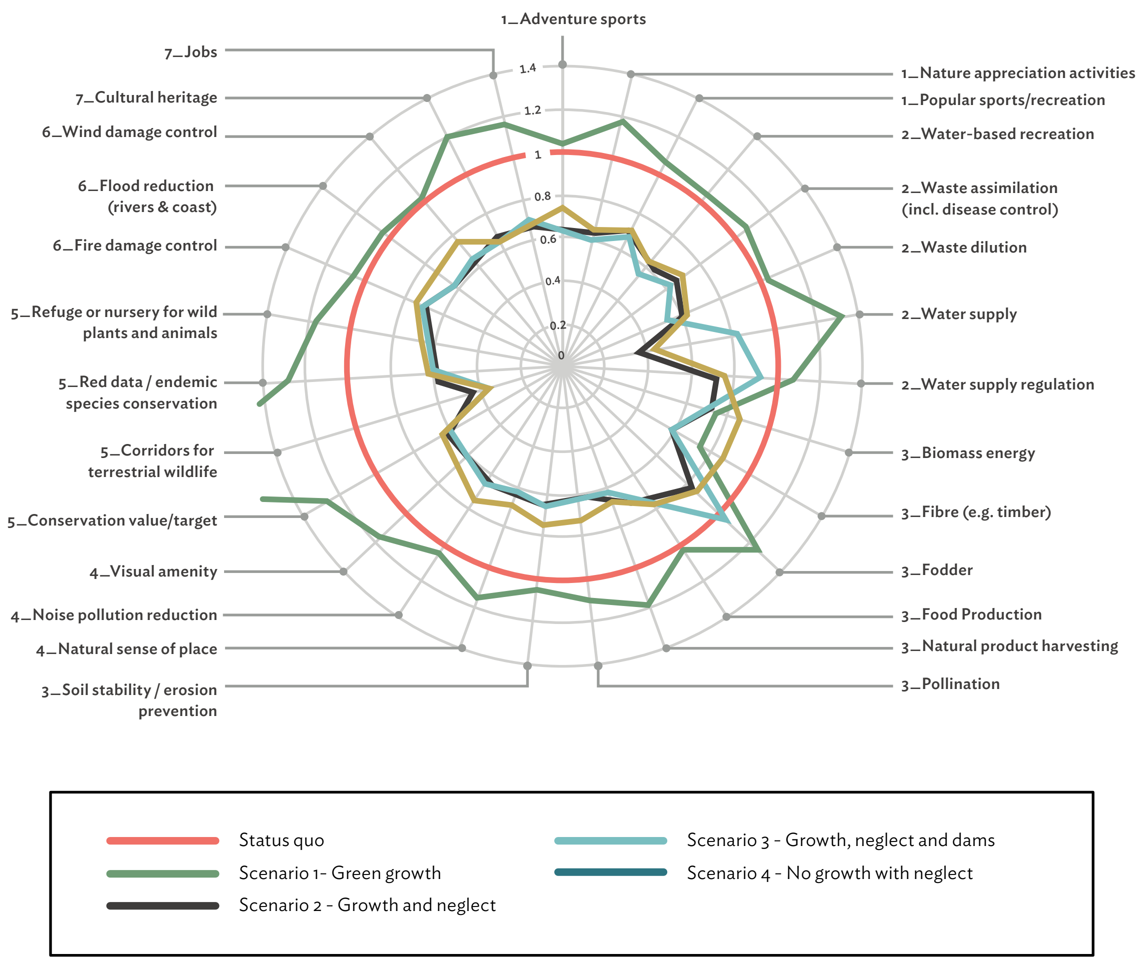
The intention of the work was to motivate the national Department of Water Affairs and Forestry (DWAF) to engage in a payment for ES scheme, to reward good land stewardship. However, despite involving DWAF water resource planners in the process, and gaining acknowledgement of sound research and modelling processes, there was a reluctance to adopt the research findings. The DWAF engineers requested that prior to adopting the findings, the modelling work needed to be substantiated with measured evidence of improved stream flow from within the affected catchments. They indicated that it is their obligation to assure water supply and only proven evidence would be acceptable. This emphasised the need to develop an evidence base that demonstrates the benefits of watershed management in order to motivate changes in budget allocations and planning approaches.

This project highlighted that without proven evidence of the benefits of watershed management it will be difficult to motivate substantive changes in budget allocations and planning approaches. Despite reaching some of the best valuation estimates with nationally acknowledged experts, the process was not sufficient to convince the stakeholders that DWAF needed to adopt new options. Consequently, it is doubtful that monetary valuations are going to lead to institutional changes in municipal budgeting and mandates.

Photograph by SA Tourism

Figure 4.3: A radar graph showing changes in service supply levels modelled for different scenarios. Service levels were decided on using a participatory process.

NOTE: All service types are normalised to 1 (indicated by the red line), with different scenarios depicting the relative changes in service levels.



"The case studies emphasise the need for the value of green assets to be recognised by the relevant stakeholder groups. This can be through social learning processes in either single project applications or over a long-term programme."

4.5. A social learning process for valuing ecosystem services

The collection of case studies presented in this chapter span a period of 16 years, and they suggest that valuation alone is unlikely to shift existing systems and approaches. The case studies emphasise the need for the value of green assets to be recognised by the relevant stakeholder groups. This can be through social learning processes in either single project applications or over a long-term programme. Most people are not aware of their reliance on ES, and thus part of the social learning process requires that they develop an understanding of what services they use, how they access them, what habitat produces them, where in the landscape these come from, who owns the land that produces them, and what the land owners are doing to their landscape. For each ecosystem service there is a long chain of exploration required to understand the various components (as listed above). The research required to explicitly understand each ecosystem service in each sub-catchment is considerable. Conducting such research for entire systems and broad regions is difficult due to resource and skill shortages. In addition, such research is unlikely to be widely accepted by society without building broad public confidence in the subject. Thus, an alternative approach is required.

The social learning processes described in the case studies demonstrates how municipalities' value of ecosystems and associated services can be developed. This process involves the following steps:

- Acquiring information and data;
- Sharing this information;
- Developing new insights by combining available data and wisdom in systems modelling;
- Exploring relationships between ecology, society and economy;
- Exploring possible futures with different ES levels; and
- Combining the various components to inform perspectives and choices.

It is important to note that this process is only as good as the participants and it requires the involvement of various stakeholders in the fields of engineering, ecology, hydrology, financing and the social sector. Including the perspectives from service users is just as critical as understanding how services are regarded by society and the associated value.

4.5.1. Assembling the team

Assembling the right team is critical for successfully developing recognition for the value of green assets. The team should include at least the following experts: water supply engineers, wastewater engineers, stormwater engineers, town and regional planners, disaster management practitioners, ecologists, environmental managers and hydrologists. This group of experts is well-positioned to identify ES and supply levels. Once some progress has been made in gaining a clearer idea of services supply levels, the team should be broadened to include social services, municipal finance, transport and health. These groups are closer to the demand side of ES.

In addition, a champion is also needed for a successful valuing process in the municipality. The success in eThekwini has largely been the result of a municipal official who championed the concept of ES and consistently reinforced the thinking in municipal planning and management processes over the course of many years. It is necessary to identify municipal officials who are receptive to the concepts of GI and green engineering, and to ensure they are included in the process. Getting early buy-in is critical to a successful valuing process. In this regard, carefully crafted communications and lobbying is necessary from the start. Success stories from other locations are useful in gaining support. Securing commitment from stakeholders to a series of continuous interactions over an extended period is also necessary. The process should be made clear from the onset, and it should closely involve the other related activities and be embedded in developing an overall strategy.

4.5.2. Recognition of assets

The next step in the process is to identify the green assets within the area of concern. This requires that the boundaries of the social-ecological system are identified and agreed upon. The boundaries should only include key supply and demand areas where the municipality has control. The process will require detailed GIS work to specifically map land cover.

4.5.3. Identify services that are generated by assets

Each land cover type provides a different suite of ES at different supply levels. For example, grasslands supply good flood attenuation services but are poor at supplying energy. Each land cover type needs to be assessed to determine what services they supply, which can be done through the social learning process where the team explores service delivery potentials from the different natural and transformed land cover types. Ecologists and water engineers play a key role in this aspect of the work. Identifying service delivery potential can be done through a participatory workshop where published knowledge and local experiences are shared and new insights are generated.

This is an important step in changing mindsets. The team needs to explore the services and develop consensus on local potential supply capabilities per hectare. These potentials can then be combined with the size and condition of assets to generate relative service supply levels for the landscape. This helps shape expectations regarding which services a particular geographical area, such as Gauteng, is able to supply well, moderately and poorly. These form the initial local development constraints and opportunities. Therefore, the data can be mapped to show areas of high, moderate and low ES delivery. In this process municipal officials are able to see how and to what extent green assets support their departmental service delivery mandates. This helps to develop consensus on the role that ES play in the municipality, and develops recognition of their value to service departments.

4.5.4. Identify benefits of assets

After developing a sense of ecosystem supply capabilities, the team can develop an understanding of service demands and their benefits. This will require an assessment of demographic data to determine the household use of ES, and the location of the ward-level demand for services. This can be restricted to those services, such as water supply and human waste management, which both built and natural systems can supply. This information is then used to identify the numbers and location of people using the services. For example, identifying how many people live on floodplains. The levels of dependence should also be explored. For example, ascertaining how many people's lives are saved per year by reduced flood levels due to good upstream land cover, or does it merely save travel time when a low-water bridge is flooded once every two years. Mapping the demand or use of services can reveal existing spatial relationships.

By combining the number of people affected and their levels of benefit, a benefit score can be generated, similar to the United Nations Human Development Index (HDI) (Klugman et al., 2011). This provides an indication of how many people benefit from each ecosystem service, which then allows the services to be ranked in terms of societal benefits. The process of valuing ES should include the benefit score (which the team generates with good credibility), and the monetary value generated by economists which shows orders of magnitude values (but has limited credibility and transferability). Published evidence of values, such as De Groot et al. (2012), can be used to adapt known values per hectare from relevant studies, and multiply these with the hectares of assets in the study area to provide indicative monetary values. These monetary indicators highlight the unaffordability of ES losses to the finance departments.

4.5.5. Explore the acceptability of service levels

The next step in the process is to explore the acceptability of current service levels. For example, is the figure of 500 poor households flooded on an annual basis acceptable, or not? Is the water quality in the local river in which 10 000 children play a year acceptable, or not? This phase of the process would be supported by statistics on negative environmental outcomes such as pollution events, disease outbreaks, medical treatment costs, veld fire frequency and severity, and flood damage and costs. If such events occur or already exist in the study area, then either the size or the condition of associated ecosystems (natural or transformed), is not adequate and improved management is necessary. Again, the emphasis here is less on the monetary implications, than the moral and welfare implications, which develop buy-in. The acceptability of service levels can also help to identify households or areas that are vulnerable to either current or future threats.

4.5.6. Explore future urban landscape scenarios and generate likely changes in service levels

A key element of the valuing process is to explore the consequences of future scenarios with better or worse ES levels. Scenarios development can be an excellent platform to explore possible futures, without being threatening for the participants. The process of developing plausible futures with different states of GI helps to build an understanding of the implications of varying degrees of green asset management. A focus on scenarios also means that participants can easily agree on a desired future, and therefore the kinds of actions necessary to generate the desired future. The scenario development process requires a combination of participatory and systems modelling. The process builds on the supply and demand assessment by postulating what the size and condition the existing land cover may be like based on different future land use and management options. A systems model then predicts future service level scenarios that either increase or decrease, depending on these land use and management options. The model also allows the demand for services to be increased or decreased based on projected population growth and dependence on services, according to what the team considers plausible. Risk in the model can be reflected by comparing the future supply and the demand outcomes. For example, a growing demand with a stable supply will indicate an increased risk or livelihood vulnerability due to the increased pressure on the service supply. Another scenario may show a decline in supply and an increase in demand, which would indicate an exponential increase in risk.

A thorough investigation of future scenarios builds team understanding of the social-ecological system, and makes the direction and magnitude of changes clear, including the implications for each department. This process establishes the role of ES and therefore the value of GI in municipal service delivery. In this process, team members begin to make sense of ES and the land cover types from which they are derived, and potentially to internalise the value that GI adds to individual departments. Furthermore, the process highlights both desired and undesired future scenarios, and shows which land use and management options promote the various future scenarios. In this way, participants discover for themselves what they need to do to ensure that green assets work to support their departmental mandates. When these departments start to direct future work programmes to maintain and invest in GI, green assets begin to be valued.

This process is strengthened if it can draw on reliable population growth projections, land transformation rates, servicing levels trends, water quality management capacity trends, etc. The more credible the projections are, the more plausible the predicted futures will be. The scenario development process is likely to be the biggest single time investment required by the team, and the effectiveness of this process is improved by preparing all available information in advance of the systems modelling process.

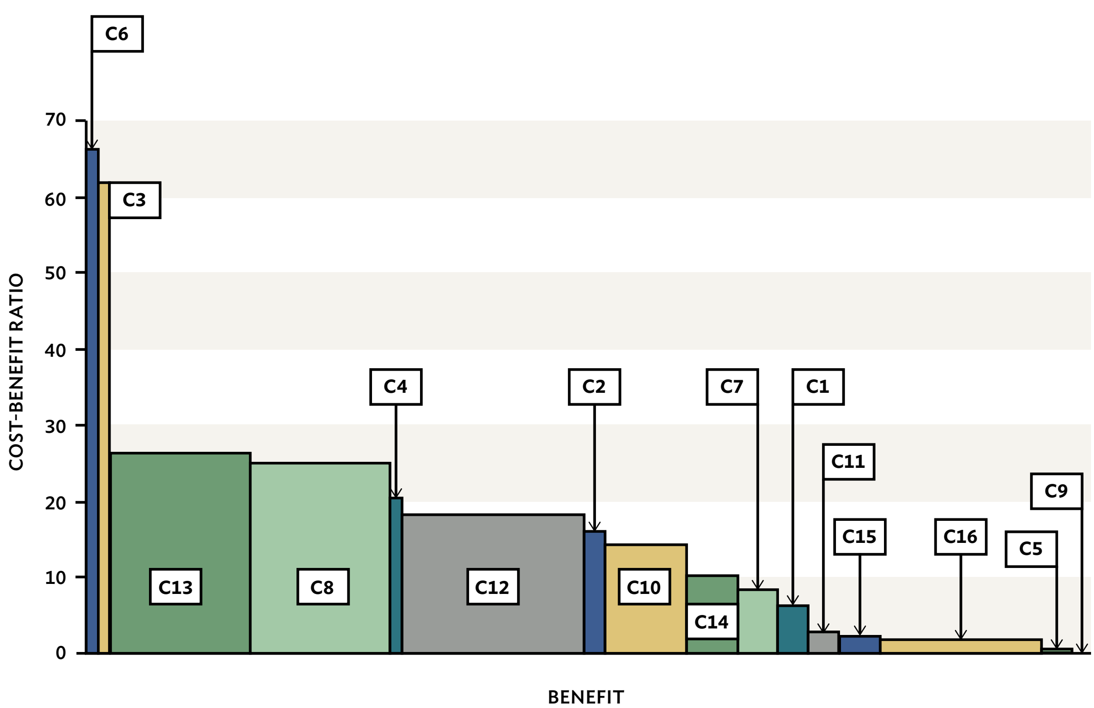
4.5.7. Identify cost-effective management actions necessary to supply desired service levels

Once consensus on the desired future scenario has been reached, the specific management actions required to achieve this can be explored in more detail. Once a list of these actions has been established, their monetary value will need to be estimated. It is likely that the total costs of the proposed management actions will exceed the available budget. Ranking the key actions in terms of cost-effectiveness is thus an important process to prioritise current and future work plans and budgeting. It is also necessary to compare the cost-effectiveness of GI against built infrastructure solutions in order to make informed choices on the optimal solution. This process should compare both the financial costs and the human benefits of the different options. Figure 4.4 provides an example from eThekwini of how this comparison can be depicted. Both the height and width of the histogram columns are important as the height indicates the cost-benefit ratio, and the column width indicates the magnitude of the human benefit. In this example option C13 would be the best option as it is the third most cost-effective solution and has the largest human benefit impacts.

A cost-benefit analysis such as this promotes informed decision-making, especially when dealing with complex social-ecological systems with uncertainty, and where investing in GI may enhance multiple services for multiple user groups, with different levels of benefits.

Figure 4.4: An adaptation costs curve used to compare different intervention options in a particular climate change scenario: Ready for the storm (50 years)

SOURCE: Cartwright et al., 2013



4.6. Conclusion

This chapter has described the importance of moving away from valuation exercises and towards facilitating social learning processes, which develop an appreciation of the value of green assets. In these processes, financial valuation plays only a part in developing values, and is not the primary aim of the process. Overall, in urban contexts, ES supply is declining due to the fact that they are undervalued by government and society. A shift in this system requires deployment of a social learning process to build the value of green assets into municipal systems. There are no silver bullets or quick fixes in a democratic system, and the process of developing value in GI is likely to be time-consuming, and will rely on officials being motivated to engage in the process of developing values for ES and finding alternatives to current approaches. This process is reliant on a platform where a participatory social learning process can unfold and where the value of GI can be developed so that it becomes accepted, internalised and grown. Once this value has been generated and translated into a demand for the maintenance or enhancement of ES, then financing options can be considered.

Photograph by Christina Culwick

5. Scoping a process for the design and uptake of combined grey-green engineered solutions, as part of a green infrastructure plan

*WRITTEN BY STUART DUNSMORE**

5.1. Introduction

Through the provisioning of ecosystem services (ES), green infrastructure (GI) can provide multiple benefits for municipalities and society, including the reduction of infrastructure costs. This chapter presents a set of GI alternatives that can easily be implemented by municipalities and will help build the support for a GI approach. The list of GI types presented here does not constitute a comprehensive list, but serves to build recommendations for wider application and uptake by local government in the Gauteng City-Region (GCR). These recommendations are developed through understanding international best practice around GI alternatives for grey infrastructure and in positioning the uptake of grey-green design solutions within municipal planning and infrastructure development.

Existing environmental programmes within the City of Johannesburg (CoJ) and Ekurhuleni Metropolitan Municipality (EMM) are used as a guide to begin to understand the requirements and opportunities for incorporating GI into planning processes and strategic programmes. The insights from these two municipalities are used to make broader recommendations and provide examples for the application of a GI approach in the GCR. Stormwater management is identified as a potential breakthrough sector that could benefit most from the uptake of a GI planning approach. This chapter identifies specific GI applications that will have particular relevance to the management of stormwater in the GCR. The ultimate aim of this chapter is to provide insight into the role and potential for GI to be applied through the development and implementation of 'shovel-ready'[11] GI projects, and to identify a process that will be required to justify and design these projects in the GCR.

5.2. GI services for shovel-ready projects

ES can be divided into three broad categories of services namely provisioning, regulating and cultural services. Inherent within these is the enhancement of ecology and biodiversity which supports the provision of the services. Cartwright and Oelofse (Chapter 3) reflect on the valuing of ecosystem goods and services in the City of Cape Town (CoCT) and highlight the difficulty in convincing those responsible for planning infrastructure to consider investments in GI and ES. They report that despite evidence from a comprehensive valuation exercise, municipal departments responsible for investment decisions have difficulty in accepting the multiple benefits that are provided by GI, especially where they appear intangible as they are not observable, where the benefits involve reducing risk and avoided damage, or where the benefits may only be realised at a later date. As such, the uptake of a GI approach in municipal projects can be a slow process.

In an attempt to identify shovel-ready projects, projects have been identified where municipalities may be able to observe the benefit of green assets in the short-term, even if these are limited to a narrow focus on specific services or the replication of services offered by equivalent grey infrastructure. The identification and development of shovel-ready projects can provide critical opportunities for the uptake of GI in traditional infrastructure planning.

From discussions with various municipal representatives, a number of direct services (and indirect benefits) have been identified as quick wins in terms of the potential for GI to be included into municipal projects. GI can be easily included into the following municipal programmes while supporting job

* Fourth Element Consulting

11. Projects that have obtained support and approval from the relevant departments, and are able to be implemented (See Section 3.6.9).

creation and public wellbeing: agriculture, land and soil protection, water resources management (quantity and quality), flood and drainage management, climate and temperature control, recreation spaces, and buffer zone protection.

Table 5.1 presents an example of specific GI options identified by the United States of America (USA) Environmental Protection Agency (EPA). Here the aim is to guide developers, municipalities and city departments on the kinds of systems and techniques that can be used to control stormwater runoff in a manner that approaches a natural system. In comparison, the City of New York (2014) has a list of GI solutions more suited to inner city areas (Table 5.2). Given that there is a range of grey-green alternatives, it is important for municipalities

Table 5.1: Examples of green infrastructure

SOURCE: EPA, 2014b

Green Infrastructure	Application
Downspout disconnection	Disconnection from the storm sewer network to one of the systems below
Rainwater harvesting	Capture at source for local use
Rain gardens	Shallow, vegetated basins that collect and absorb runoff
Planter boxes	Typically suited to densely developed areas (central business districts, etc.)
Bioswales	Linear facilities particularly suited to roads and large paved areas
Permeable pavements	Particularly suited to pedestrian and parking areas and low-volume /low-speed roads
Green streets	Incorporates many of the above facilities into street design
Green parking	Incorporates the above, particularly porous paving, rain gardens and bioswales
Green roofs	Can be expensive, especially when retrofitted and is better suited to multi-storey buildings
Urban tree canopy	Increases rainfall interception, but also helps control ambient temperatures
Land conservation	Protecting green open spaces and sensitive natural environments

Photograph by Christina Culwick

to decide for themselves which assets suit their particular goals.

It should be noted that the uptake of GI is often associated with stormwater management, and therefore aligns with the Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID) and Water Sensitive Urban Design (WSUD) (see Box 5.1). However, it is important that not all features of the planning concepts listed in Table 5.1 are assumed to be GI.

Box 5.1 Sustainable drainage

As the pressures for urban development have increased over the last few decades, the limitations in the 'traditional' methods of stormwater management have emerged. The principles of source control (controlling rainfall-runoff where it falls) began to gain traction in stormwater design in the 1980s in the USA and Europe, and in the past 15 years has led to integrated drainage management guidelines including SUDS (developed in the United Kingdom (UK)), LID (applied in the USA) and WSUDs (applied in Australia). Each of these follow the principles of runoff volume control (rather than just peak flow control), improving conditions of quantity, quality and amenity. The guidelines apply to both new development and retrofitting established developments. While they promote storage and infiltration, and include vegetated solutions, they also include new technologies for pavement design, rainwater harvesting, etc. that have limited ecological potential and would still be considered grey infrastructure.

Similarly, not all urban green spaces should automatically be qualified as GI. An area of mown lawn, for example, or a vegetated road island as specified in CoJ's Complete Streets guideline (CoJ, 2013), may not qualify as GI if it provides no measurable services. This is an important consideration as 'stormwater green streets' facilities identified by the City of New York (as identified in Table 5.2) may appear similar to facilities in the CoJ Complete Streets, but they are specifically designed to collect and manage stormwater from the streets and pavements, and can thus be classified as GI.

The provision of services is, therefore, an important aspect of GI, and these need to be specifically planned and designed to provide a particular service. This would apply directly to existing features and open spaces, where services are identified as part of a planning process, or quantified in a design process. The performance of these services should be able to be measured and monitored in some way, just as the same applies to grey infrastructure. Under these circumstances, GI should be designated as city assets, afforded equivalent status as other infrastructure assets, and afforded the same management and maintenance support.

In order to do this, municipalities in Gauteng need to begin identifying GI solutions that are relevant to the Gauteng context, as this will help them work towards identified targets (e.g. stormwater management). The selection of services and relevant GI is likely to be influenced by specific municipal initiatives, institutional structures, local environmental and/or social issues, rehabilitation targets, or climate and habitat restrictions. In many cases these will differ from the needs of places in the USA, UK and the European Union (EU), and regional solutions and alternatives would need to be developed over time.

Table 5.2: Examples of green infrastructure used in City of New York

SOURCE: EPA, 2014b

Green Infrastructure	Application
Right-of-way bioswales	Vegetated installations on street pavements that retain and infiltrate a proportion of stormwater runoff.
Stormwater green streets	Similar to the bioswales above, but constructed within the roadway and are therefore larger in size, with greater potential for runoff control. *(This is very similar to the guidelines in the CoJ Complete Streets)*
Green roofs	Vegetated roof areas. Better suited to multi-storey buildings with adequate column support.
Blue roofs	Similar to green roofs but with infiltration media and rooftop water storage rather than a vegetated system.
Rain gardens	Shallow, vegetated basins that collect and absorb runoff.
Permeable pavements	Particularly suited to pedestrian and parking areas and low-volume/low-speed roads.
Sub-surface detention systems	These are constructed under or near paved areas and often in conjunction with permeable paving and similar infiltration systems. They detain the runoff volume, allowing more time for deeper soil infiltration.
Cisterns and rain barrels	Rainwater harvesting facilities, storing rainwater runoff for alternative uses.

5.3. Opportunities and limitations in Gauteng

The opportunities and limitations for the uptake of a GI planning approach have been revealed through municipal officials' experiences in EMM and CoJ. Through a set of interviews conducted in 2014, a list was developed of the projects currently being undertaken by the respective environmental departments (Table 5.3). Engagement with officials also revealed the opportunities and limitations for the uptake of a GI approach within municipal programmes. The projects and programmes discussed here have a bias towards stormwater and water resources services, which are a common theme for many GI programmes.

5.3.1. Opportunities

The GCR has an enormous wealth of green assets that together form an extensive multi-layered network, which is yet to be formally classified as GI. Municipalities are currently building the foundation for investment and development of green assets. Discussions with municipal officials indicated an awareness of the concept of GI, despite varying interpretations. Their understanding of the term tended to align with the respective departmental mandates. What was clear, however, was that there is no co-ordinated approach towards introducing and developing green assets with attention being placed on site-specific opportunities. Examples of such opportunities include:

- Park developments and upgrades;
- Street improvements (e.g. through the CoJ's Complete Streets guideline);
- Selected flood management, river rehabilitation and drainage management schemes (e.g. Kaalspruit in EMM and Queen Road Wetland, CoJ);
- Selected green roof installations (Johannesburg

Photograph by Clive Hassal

City Parks and Zoo (JCPZ);
- Selected agricultural projects (EMM and CoJ); and
- Spatial planning initiatives for landfill buffer zones (EMM) and cemeteries (CoJ and EMM).

It is noted that all these site-specific options include opportunities for formal GI components to be included in the existing plans and designs.

5.3.2. Limitations

Municipal officials identified a set of barriers for the rollout of GI at a project level. These are presented below, and refer to specific barriers that relate to planning, funding, institutional arrangements, licensing and compliance, maintenance and design standards.

5.3.2.1 Planning

There remains limited communication and co-operation between key departments, despite a number of departments being present at planning forums. Part of the problem may be that detailed planning requirements (e.g. for stormwater control) are not in a format suitable for use by planning departments. Hence is not always provided for the sufficient stormwater volume and water quality control on a catchment scale. As a result, stormwater departments feel they are left to work with what space is left over. This constrains opportunities for GI which often needs more space than grey infrastructure to provide equivalent services, perhaps especially in the Highveld[12] environment.

Catchment stormwater planning has only recently been reintroduced into the thinking of municipal stormwater management. Many of the stormwater management plans are still relatively new and perhaps not fully incorporated into daily operations at departmental level. It is clear that GI is most effective if developed through spatial planning, as the benefit of the whole system is far greater than the sum of the individual site initiatives. The design of site-specific projects can be optimised if they are also aligned to achieve specific catchment targets. However, in a weak planning environment the role of green assets in the infrastructure network may not be fully realised. As such, responsibilities for the uptake of GI in municipal planning should be taken on by all municipal departments and it is recommended that these initiatives should be undertaken by the custodians of GI to ensure that these assets (or key sites or development guidelines) are identified in digital spatial datasets.

12. The Highveld region comprises an area in the central plateau of South Africa that is characterised by a temperate climate, dry winters and wet summers with short duration and high intensity storms, and a long dry season.

Table 5.3: Current projects within EMM and CoJ environmental and stormwater departments that can accommodate a GI planning approach. Text in italics provide additional information.

Project type	Primary agent (custodian)	Stakeholder departments (examples)	GI measures (examples)
Parks development (new) and upgrades (existing)	Parks *(and/or nature reserves)*	Roads and stormwater	Identify and formalise stormwater services (attenuation, retention, etc.). Identify surface water treatment services (wetlands, swales, etc.).
		Infrastructure or transportation (for pedestrian traffic	Establish and formalise pedestrian routes, accessibility, safety, etc.
		Planning (various)	Integrated environmental management.
Cemeteries	Parks	Social and cultural	Opportunities for innovative land use (e.g. use of buffer zones) or creation of environments for burial (e.g. JCPZ's forest initiative at Olifantsvlei Cemetery).
Public transport and non-motorised transport routes	Roads/infrastruc-ture/ development agencies	Roads and stormwater and Parks	Development of green streets designed for infiltration and retention. For example implement Complete Streets initiative, but include specific planting and stormwater targets.
		Parks *(JCPZ is already active on this)*	Increase tree and leaf canopy, maximise rainfall interception, aim for air quality management targets.
		Economic development	*Yet unknown*
Inner city parks	Parks	Roads and stormwater	Develop parks as part of a network of GI, e.g. integrate with Complete Streets initia-tive with planter boxes, vegetated islands, as well as green roofs. *(Inner city high-rise buildings are better suited to retrofitting green roofs).*

Project type	Primary agent (custodian)	Stakeholder departments (examples)	GI measures (examples)
Greening surfaces, *(e.g. roofs, parking areas, verges, etc.)*	Yet unknown *There will typically be specialised design requirements better suited to an engineering department (e.g. roads and stormwater), but parks will also provide key expertise and maintenance capacity*	Roads and stormwater Parks Possibly planning and development control	Implement systems that maximise infiltration and retention, and possibly include rainwater harvesting. This may be a new initiative lead by one department or spread among different departments working towards a common target. *Experience is growing; JCPZ already has early experience in green roofs and EMM is implementing green verges.*
Urban agriculture	Yet unknown *Both EMM and CoJ are working on plans for urban agriculture, but this needs more investigation*	Parks	Needs further investigation. *JCPZ is already involved in a number of initiatives, but details are not known.*
		Roads and stormwater	Runoff harvesting (instead of rainwater harvesting). This will include stormwater management planning and infrastructure planning and design (e.g. retention facilities such as constructed wetlands).
		Planning and development control Catchment management	Implement controls to manage water quality in catchment runoff.

Project type	Primary agent (custodian)	Stakeholder departments (examples)	GI measures (examples)
New roads and roads upgrades *[In association with rivers and streams (see below), roads provide linear linkages across municipal areas. Greening the road networks where possible will assist in integrating the GI network].*	Roads and stormwater	Parks	Both EMM Roads and stormwater and CoJ Roads Agency (JRA) continue to revise and update their road designs incorporating more soft engineered systems. These include road islands, swales and green verges. The JRA 'Complete Streets' manual sets out the concepts in some detail, but design guidelines are limited, reflecting a lack of confidence in the application of international guidelines to Highveld conditions. Pilot studies and research are needed.
Flood management, including river rehabilitation and erosion protection *[Rivers, streams and drainage lines are excellent linear green systems that will assist in integrating the GI network].*	Roads and stormwater	Parks	Soft engineered solutions to be a priority, requiring vegetation planning and management. This will include enhancing natural systems (e.g. wetlands), constructing new wetlands, the use of reed beds, swales, and energy management by riffle-pool sequences. All these have the potential for habitat enhancement.
		Parks	River and stream corridors are prime parkland and recreational space. Security is a problem to be overcome.
		Planning and development control Catchment management	Catchment management should be an integral part of stormwater management and water quality control.
Dams, wetlands and pans	Roads and stormwater and/or Parks	Roads and stormwater	These facilities have important (sometimes critical) water resource management functions (quantity and quantity) and flood management functions.
		Parks	Each will have opportunity for enhanced habitat and biodiversity, as well as recreational services, which need to be managed in association with the water resource and flood services.

Project type	Primary agent (custodian)	Stakeholder departments (examples)	GI measures (examples)
Power line servitudes *[Like rivers and streams, power lines servitudes are an opportunity to integrate a GI network].*	Possibly Parks	Roads and stormwater (for servitudes along river corridors)	Research by Eskom has vastly improved the servitude management and operational requirements that allow for a much greater diversity of vegetation along power line corridors. While the primary function must be to ensure the safety and operation of the power lines, servitudes can be developed into biodiversity corridors with recreational functions. Maintenance will be required.
Buffer areas around landfill sites	Waste management agency	Parks	EMM is considering alternative uses for these open spaces, including: Cemeteries Agriculture Possibly others
Housing projects and township planning and establishment	Possibly housing planning and development control	Roads and stormwater	Implement the GI associated with new roads mentioned above. Apply catchment management strategies for stormwater runoff.
		Planning and development control Catchment management	Oversee catchment management plans and implementation.
Private development	Planning and development control catchment management	Roads and stormwater	Advise on restrictions for stormwater discharge (volume and quality). Approval of Spatial Development Plans and sign-off construction. Maintenance = policing management and maintenance of stormwater control facilities.

5.3.2.2 Institutional arrangements

Due to the range of services provided by green assets, multiple departments have an interest in and responsibility for the management of GI. The South African Institute of Civil Engineering (SAICE) (2011) reports on the implications of the overlapping responsibilities where diversified responsibilities result in competing priorities, resulting in non-sequential project completion due to the lack of co-ordination across departments. This highlights the need for co-operative governance, which is not always supported by current institutional structures in the GCR.

There needs to be a common understanding between departments on what constitutes GI, their services and their requirements. This may support greater planning and co-operation between departments that can filter down to maintenance activities. The model used by the eThekwini Municipality for 'mainstreaming the climate change debate' provides a good example for overcoming these barriers (Roberts, 2009).

Shared financial allocations and greater inter-departmental co-operation around GI will assist with planning. For example, catchment planning is undertaken with defined water quality and storm volume targets, and these in turn point to targets for limitations on paved areas, water retention and attenuation requirements. Other departments are aware of these requirements and plan for them accordingly by securing their own budgets in coming years.

5.3.2.3 Funding

GI is typically managed by several departments, however, not all of which have specific budget allocations for the required maintenance. For example, the management of streams and rivers has traditionally been the responsibility of the roads and stormwater departments in CoJ and EMM, despite this not being the department's core business. As a result, funds for stream rehabilitation, maintenance and erosion control are allocated from the operational budgets for roads, and thus these green assets receive low priority. It can be argued that the responsibility for maintaining streams would be better placed in departments (e.g. Parks) that are better placed to source the appropriate funding.

According to a report by SAICE (2011) on the status of the national infrastructure, asset databases were generally in a poor state. This makes preparing maintenance programmes difficult, and in turn, makes it harder to motivate for adequate budget allocations. Efforts should be made to maintain asset databases that record both grey and green assets using a digital spatial database such as GIS. Establishing a comprehensive asset database of existing and planned green assets, with clearly defined services provided to the municipal area, is an important step towards municipalities securing control of these assets. This will play an important part in ensuring that these assets function effectively and sufficient maintenance budgets are allocated.

5.3.2.4 Maintenance

Limited capacity (skills and funding) for maintenance of assets is perhaps the primary concern of all departments interviewed in this study. This affects existing assets at all levels, and is perceived to be a weakness of all municipalities in Gauteng and South Africa as a whole (SAICE, 2011). Skills

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"Despite a generally positive view on the benefits of GI, there is a notable reluctance among various departments to accept responsibility for implementing these facilities in the short-term, particularly if there is a great likelihood of failure due to lack of maintenance."

shortages often lead to poor management and the inability to spend the maintenance budget. This undermines the ability to motivate for more budget in future budgeting cycles, thus perpetuating the challenge.

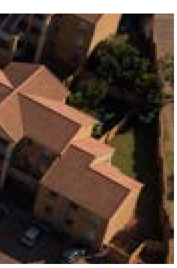
An example of this is where rivers and streams are managed by roads and stormwater departments, due to the flooding risk. These departments may not have the required experience to maintain streams or the facilities to manage vegetation (e.g. watering, cutting, weed removal). In addition, they cannot work in the stream without a water use license and cannot work above the water line, as this area then falls part of the responsibility of parks departments.

Maintenance also includes a requirement for monitoring, which is important for the management of all assets, including GI. Despite a generally positive view on the benefits of GI, there is a notable reluctance among various departments to accept responsibility for implementing these facilities in the short-term, particularly if there is a great likelihood of failure due to lack of maintenance. In response to this, it is not unusual for design engineers to produce designs that claim to be 'maintenance-free'. There is no indication that green assets cost more to maintain than conventional grey assets but they do require alternative maintenance measures and a clear understanding of their function.

Maintenance requirements can be reduced by good design, or increased by poor design (SAICE, 2011). Maintenance will, however, always be required, and the extent of this maintenance will influence lifecycle costs. These, however, are seldom considered in the procurement of infrastructure design and construction, which tend to focus on the lowest capital costs. Consequently, appropriate designs are often not employed (SAICE, 2011).

5.3.2.5 Licensing and compliance

All operational departments raised the concern that project implementation and maintenance needs to comply with the National Environment Management Act (NEMA) (Act No. 107 of 1998), the National Water Act (NWA) (Act No. 36 of 1998) and associated regulations. As a result, municipalities do not feel free to manage and maintain their own assets. The relationships between municipal departments and the Gauteng Department of Agriculture and Rural Development (GDARD) are improving, but are still not at a suitable level for efficient asset planning



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and maintenance. There are reports of councillors and municipal officials who have faced prosecution because they have not applied for the necessary licences to maintain the environment before removing reeds in river channels that have contributed to flooding disasters. Obtaining licenses for maintenance in streams, which are already altered due to their urban environment, takes time and complicates planning and maintenance functions within municipalities. Legal compliance is therefore often seen as an impediment to municipal operations. This has led to reduced functionality in some cases (see maintenance section above).

There is no question around the fact that environmental and water resources need to be protected, but it is not clear whether interventions should be the responsibility of provincial government (GDARD) or the national Department of Water Affairs (DWA). Certainly, experience in both CoJ and EMM suggests that areas of severe water pollution are evident with little involvement of the DWA. The NWA has the facility to devolve decision-making to local levels and there may be a similar facility within NEMA. It may be argued that municipalities would be better positioned to monitor and regulate their own environments, particularly in maintaining municipal assets. Defining GI as assets, owned by the municipality, may therefore be a way of reducing the impact of legal non-compliance.

Although arrangements between municipalities and provincial government are outside the scope of this exercise, in the short-term, environmental impact assessments (EIAs), environmental management plans and water use license applications need to be specific about maintenance requirements so that maintenance can take place without licences being required.

5.3.2.6 Design standards

The design of GI for providing water resource and stormwater services is a concern for the municipalities in the GCR, particularly where there is uncertainty around whether international guidelines are applicable to Highveld conditions, and the suitability of indigenous vegetation to GI options. In addition, maintenance requirements may not suit current municipal capacities.

These concerns are not without reason as it takes time to develop and test systems for suitability in a local environment. A handbook for Australian design of WSUDs (Argue, 2004) was the culmination of 15 years of research and pilot studies. But while there is no doubt that there is a need for case studies in the Highveld region, standard design solutions may be easier to adapt than anticipated, because the Australian conditions are similar in many respects to Highveld conditions. This implies a common base for many of the engineering design methods. However, local experience still needs to be developed for the use of Highveld indigenous vegetation in green asset designs.

Good design is a critical part of the success of stormwater facilities that have WSUDs and/or GI features. Urban stormwater design is a specialist area of civil engineering, as is road design. Similarly, landscape design for water services systems is best in the hands of experienced landscape architects who will need to work closely together to adapt international design guidelines to suit Highveld conditions.

Progress is already being made in this regard, for example the JCPZ green roofs project provides a good baseline from which to start the design standards on green roofs. Experienced stormwater design engineers in conjunction with experienced landscape architects can build on this with relatively limited risk, although some assets (e.g. permeable paving) may benefit from pilot installations. In the long-term investment should be made into pilot studies and research into Highveld suitable designs of GI facilities. Such facilities could include local applications of porous surfaces (paving, asphalt and concrete), green roof and roof garden applications, planter boxes for inner city applications, and larger systems for water treatment and retention. Opportunities for runoff harvesting for agricultural purposes should also be considered in the GCR.

> **"Good design is a critical part of the success of stormwater facilities that have WSUDs and/or GI features."**

5.4. Scoping green infrastructure requirements for shovel-ready projects

5.4.1. Project processes

The process of preparing projects to a shovel-ready status usually involves a series of design related stages including: a feasibility analysis, a design process that may include separate concept and detailed design stages, and the preparation of a Bill of Quantities followed by a tender process where contractors are invited to bid for the construction work. During construction there is a monitoring phase that should ensure that both the design and construction meet the aims of the project, and that adjustments and corrective actions are implemented. Thereafter, there is a period where the contractor ensures the establishment and rehabilitation of the site before handover to the municipal departments responsible for the operation and maintenance of the asset.

The stages in the process may vary according to the size and nature of the project, and to the procurement processes specific to each municipality. For example, feasibility studies may not be necessary where standard design guidelines are available, and even the concept design stage may be left out. In certain circumstances, stormwater design may even be left to the contractor to prepare. This is typically where standard grey infrastructure systems and design options are used.

Currently there are no adopted design standards for GI; it is thus recommended that the formal design stage is maintained in all cases and that specialist stormwater engineers and landscape architects are appointed for this particular aspect of a project. The implementation should be defined by the relevant municipal department (e.g. JRA) and may vary between municipalities in the GCR. Over time, a set of standards suitable for Highveld conditions will develop, which should allow the design function to be devolved to later stages in the project process. For example, many of the drainage and landscape features of 'Complete Streets' may fall into this category in time.

On larger projects, the design process becomes less standard and more specialised. Concept designs are more important in these cases, particularly where landscape design input is required. On these projects it is important that the landscape architect is an integral part of the design process as both system function and maintenance are considered in detail.

At the planning scale, the approach may vary depending on the particular focus of the plan. Green assets providing air quality and local climate control services may focus on tree canopy and biomass on a municipal ward or region scale, whereas GI providing stormwater services will be assessed on a catchment scale. Hydrological modelling is a very useful tool for integrating stormwater system services and setting catchment runoff control requirements. Continuous simulation modelling techniques can assist in assessing the performance of different services (e.g. runoff volume reduction, peak flow attenuation, water quality management), and can also help in assessing the performance of certain vegetated systems across seasonal changes. In developing projects and planning for GI at a system scale in the GCR, it is critical for these considerations to be taken into account. This will require a clear understanding of the requirements and objectives of the project or plan (e.g. climate change mitigation, stormwater control, microclimate regulation). These requirements will guide the overall planning process.

5.4.2. Design requirements for stormwater management

The design of effective stormwater management systems, whether they are at a site level or at a catchment level, has become a specialist branch of civil engineering. Design requirements vary from location to location even though the design principles may stay the same. If GI is to perform specific services then these too need to be afforded proper specialist attention. Important considerations will vary between project types, but examples include:

- System hydraulic capacity under different vegetation types,
- System stability under a range of flow conditions (e.g. erosion resistance),
- Suitability of vegetation, particularly after the dry winter season and early wet season function,
- Aesthetic aspects such as wet and dry season differences, post flood conditions and litter management,
- Site establishment, in other words the time it takes for the vegetated system to reach full functionality,
- Risk of alien infestation and impact on system functionality, and
- Maintenance requirements.

Design requirements for stormwater services are best defined within the context of a catchment plan. Applying the same approach to stormwater attenuation to all sites within a catchment is usually done when there is no catchment stormwater management plan, even though it may not be the best solution for properties in the different sections of the catchment. Instead, drainage engineers would prefer to set on-site drainage management requirements to comply with catchment objectives. This will become more important for the design and implementation of GI as they are able to provide a wider range of stormwater services and therefore need to be more carefully integrated within a catchment to achieve optimum functionality.

The ability of GI to provide a wide range of services provides an opportunity for creative designs. In the context of stormwater management it is a common theme in SUDS, LID and WSUD that storm volume is more important to control than storm peak. GI provides an opportunity to implement this as a catchment management target, because it provides retention and infiltration services rather than just detention. These opportunities will influence the design standard as they develop over time in the Highveld area.

"The ability of GI to provide a wide range of services provides an opportunity for creative designs."

5.5. Breakthrough actions

There are a number of projects related to GI in Gauteng that are currently in progress or are in the advanced stages of planning. In some cases efforts have been made to increase the ecological footprint in metropolitan areas. Many of these could be considered green assets if their services are defined. In order to further emphasise GI, a set of 'breakthrough actions', or projects which are likely to initiate a GI planning process at the level of local government are proposed here.

Current project initiatives within EMM and CoJ, where the intended services may be provided or supported by GI, can serve as examples of breakthrough actions (see Table 5.3). In each case a 'primary agent' is identified as the custodian of the project. In the case of a grey infrastructure development, this would typically be the municipal department that initiates the project under current municipal structures and would therefore have primary responsibility for the investment, implementation and maintenance thereof. However, for a GI project one or more stakeholder departments are identified, which may enhance the services offered by the project, and in turn these departments may benefit from the project if it is developed as a green asset. It is important that these stakeholder departments are active in the project lifecycle and may contribute skills and funding to the project, rather than just providing advice and passing comment and then walking away from it.

Under current municipal structures, GI projects will experience the benefits and limitations such as are listed in Section 5.3. Therefore, short of addressing institutional restructuring, a number of other actions are proposed:

1. **Begin to develop an asset register of GI** (or assets that may be GI), as it is important to quantify and recognise what we have.
   There is a wealth of green and open space features in Gauteng (Schäffler et al., 2013). Although few, if any, have been assigned green asset status, it provides an important baseline for the development of the asset register. This asset register can then be presented to municipal departments who are invited (even challenged) to declare their interests in the range of green features, and to state their value (or perceived importance). From this exercise a list of services may be derived and assigned to the green features. It will assist in providing a framework within which projects may be developed.
   This should not be a process that starts from scratch as there will be a substantial body of work done by the municipalities that will support this process. These include, for example, state of the environment reports, catchment management studies, wetland and ecological studies, non-motorised transport and green transport studies, etc.
2. **Identify the types of green assets and services needed in Gauteng.** This implies we have a set of plans and goals that will guide the selection. Integrated Development Plans (IDPs), Spatial Development Frameworks (SDFs), transportation strategies, climate adaptation strategies, etc. will provide a basis for this process. Additional planning may also be identified.
   If each municipal department has a set of goals or targets this should lead to better co-operation between departments as GI typically provides multiple services meaning more than one department will benefit from a single project.
3. **Mainstream GI.** Ideally all departments within a municipality need to work towards the same objectives. A common understanding of what GI is and its benefits to the municipality will be necessary to accelerate the uptake of GI projects. An approach based on the institutionalising of climate change in eThekwini (Roberts, 2009) may be considered for this.
4. **Introduce lifecycle costing in the evaluation of all infrastructure projects.** In most cases this is likely to highlight GI projects as value for money as they provide multiple services and their long-term maintenance costs should be lower.

These breakthrough actions stated above would ideally be in place for new GI projects, but can be applied to existing or planned projects. Based on the consultation with municipal officials, it is clear that there is enough interest and good intent for GI projects to work. Although these projects may not achieve their full potential (e.g. the Atlasville Flood Relief Scheme), the GI foundation is being prepared and the full potential may be achieved over time.

Implementation of the breakthrough actions would ideally need a champion (or champions) at a relatively senior level within each of the municipalities. This will be important in that it will provide support, motivation and funding to those departmental representatives who drive GI projects, and will ensure they get recognition for the efforts. The opposite may be true under current municipal structures.

"Ideally all departments within a municipality need to work towards the same objectives. A common understanding of what GI is and its benefits to the municipality will be necessary to accelerate the uptake of GI projects."

Photograph by Graeme Götz

5.6. Conclusion

Green assets need to be assigned a status equivalent to other municipal infrastructure assets. This can be initiated by the development of an asset database of all green facilities in municipal areas. To achieve asset status, the services provided by green assets need to be clearly defined. Initially the services may replicate services that are provided by equivalent grey infrastructure, but in time the services may be broadened as each municipality develops its own targets for environmental and development control. In this regard, municipalities need to select their own preferred set of green assets and services.

Green assets need to be planned and designed as much as any other infrastructure. Due to the multiple services they typically provide, a multi-disciplinary team will be required (e.g. planner, engineer, landscaper, ecologist, social specialist, etc.), and within departmental co-operation in municipal structures. The roles of the specialist team members should be clearly stated.

Green assets perform better as part of a larger system. For example, setting stormwater standards for new developments should be guided by a catchment management plan, otherwise site-specific stormwater interventions are likely to have very localised benefits, and may even make conditions worse downstream. Furthermore, a combination of assets can compound the values of the assets, e.g. integrating river corridors with the servitude along electricity lines would provide greater opportunity for habitat diversity and increase the overall value of the ecological services provided, while still providing their other services.

Recommended breakthrough initiatives that encourage the uptake of a GI approach include the following:

1. Begin developing an asset register of all green features in each municipality and engage with municipal departments to identify the value and/or services provided by these features;
2. Begin identifying the types of GI and services appropriate to each municipality;
3. Mainstream GI within the thinking of each municipality; and
4. Consider lifecycle costing for all new infrastructure development (and rehabilitation or upgrades), and include GI options.

"... a combination of assets can compound the values of the assets, e.g. integrating river corridors with the servitude along electricity lines would provide greater opportunity for habitat diversity and increase the overall value of the ecological services provided, while still providing their other services."

Photograph by Clive Hassal

Part C

A way forward

6. Synthesising insights from the Green Infrastructure CityLab on a green infrastructure approach for the Gauteng City-Region

*WRITTEN BY CHRISTINA CULWICK**

6.1. Introduction

Green infrastructure (GI), and the ecosystem services (ES) it provides, offers a unique opportunity to transcend the spatial, institutional and socio-economic boundaries used in traditional planning approaches. Managing and investing in GI requires input and buy-in from a range of stakeholders and departments, and can be used as a tool to foster co-operative and integrated governance (Lovell and Taylor, 2013). An important feature of GI is that it can provide multiple services concurrently (e.g. trees can absorb carbon dioxide while creating shade and reducing erosion). This multi-functional nature of GI has the potential to provide services across a range of sectors, such as stormwater, roads, housing and parks. The transboundary nature of GI – its value and applicability across a range of sectors – necessitates the inclusion of a wide range of stakeholders and perspectives in the creation of a GI plan (Berkes, 2009; Harris et al., 2012). This has been promoted through the Gauteng City-Region Observatory's (GCRO) GI CityLab as a way of informing a GI approach in the Gauteng City-Region (GCR).

The GI CityLab (and GCRO's Green Assets and Infrastructure (GAI) project more broadly) has adopted a transdisciplinary approach that draws on a range of stakeholder insights to ensure that the research into GI is well-informed and applicable to all the relevant stakeholders. Transdisciplinary research that draws together a range of insights to co-produce knowledge has become highly regarded in research, and in particular research that informs policy and planning (Lemos and Morehouse, 2005; Klein, 2008; Petts et al., 2008; Wagner et al., 2011). Internationally there is a growing emphasis on research that extends beyond traditional disciplines in order to understand complex, multi-dimensional problems or contexts (Lemos and Morehouse, 2005; Petts et al., 2008; Berkes, 2009). Transdisciplinary research has emerged as an approach for integrating a range of perspectives, and by doing so, develops fundamentally new ideas or frameworks extending beyond traditional disciplinary boundaries (Robinson, 2008).

This chapter synthesises the input from a range of stakeholders, which were gathered through a number of different methods. In particular, it summarises the insights gained from the three expert pieces (Chapters 3, 4 and 5), the GI CityLab – a key platform for gathering and mobilising input for the GCRO's GAI project – and other individual stakeholder engagements. The chapter concludes by highlighting how the various insights inform the vision and process for applying the GI approach in the GCR, which is presented in the final chapter of the Report.

* Gauteng City-Region Observatory (GCRO)

> **The transboundary nature of GI – its value and applicability across a range of sectors – necessitates the inclusion of a wide range of stakeholders and perspectives**

Photograph by Clive Hassal

6.2. Summarised expert insights

Each of the expert pieces is based on the premise that there is a need to shift current planning approaches in municipalities to develop better urban systems through incorporating GI principles. The expert insights (Chapters 3, 4 and 5) present the process required to develop a GI approach from different perspectives, and focus in particular on mainstreaming GI, green asset and ES valuation, and opportunities for implementing GI in municipal planning. Furthermore, the experts build the understanding of and learn from other attempts at incorporating GI into municipal and government planning and budgeting. These expert insights were presented and discussed at the GI CityLab.

6.2.1. Reflecting on Cape Town's ecosystem services valuation exercise

In the first expert piece, Cartwright and Oelofse outline the City of Cape Town Metropolitan Municipality's (CoCT) motivation for conducting a total economic valuation of GI and the process that the city followed to reach the relevant values. The CoCT Environmental Resource Management Department's (ERMD) intention was to provide evidence for the value of the natural assets in the city, and consequently motivate for these assets to be awarded higher prioritisation in planning and for additional budget for the ERMD. Despite the large financial values that emerged from the total economic valuation exercise, the results did not have the policy impact nor did they bring about the change that had been anticipated. In exploring why the impact of this exercise had been unsuccessful, it was revealed that the total economic value of GI is less valuable for a city than individual projects, where the benefits provided by GI projects can be demonstrated in comparison to other existing or potential projects.

The authors emphasise that the argument for investing in GI should be financially sound and comply with the relevant legislation and procedures. However, they posit that investment in GI needs to be undertaken in collaboration with the municipal finance department to ensure the financial soundness of the projects and buy-in from the finance decision-makers. The piece further highlights that the economic benefit of investing in GI is unlikely to be successful in shifting policy unless packaged and communicated effectively. Establishing the value of GI is therefore likely to gain most traction through demonstrating the benefits of GI projects in terms of job creation (in particular low-skilled and location-based jobs), cost savings and risk reduction. In addition, any GI plan or project needs to address the cross-boundary nature of GI in terms of departmental functions and legislative boundaries.

The piece shows that although CoCT's initial attempt at mainstreaming GI through financial means was unsuccessful, the underlying GI concepts were applied to a broader green economy argument. This has gained some traction in the City. Four green economy pilot projects were identified, and are currently being used to build the evidence base for green projects. These projects relate to dune rehabilitation, waste picking in informal settlements, composting toilets and biodiversity offsets. The City's approach has thus shifted from attempting to initiate a systemic realignment of the municipal planning approaches, towards building the evidence base of green economy projects and initiating incremental changes in the system. The authors also highlight that buy-in for GI projects is most probable if they are fully conceptualised and costed ('shovel-ready' projects), and complement existing municipal projects and plans.

6.2.2. Valuing green assets through a social learning process

The second expert piece draws on Mander's experience and describes methods for establishing the value of GI through a social learning process within municipal departments and planning. He posits that stakeholder acknowledgement of the value of green assets and their services is more important than the accuracy of financial values. He further emphasises that there is a need to develop an understanding, or appreciation, of the services provided by green assets within the urban environment and that ES can be leveraged to fulfil service delivery mandates. He reviewed projects from eThekwini and Knysna municipalities in South Africa, and described how a social learning process was followed from the start of these projects. This process provided the necessary opportunity for stakeholders to acknowledge the benefits and services provided by green assets, and to identify the number

Photograph by Brenden Gray

of people that benefit from these services. This type of co-produced understanding empowers decision-makers with tools to make more accurate assessments of GI investments as the benefits and services derived from green assets become clear. A strong argument can be made for a GI approach through this process as it frames green assets in terms of the benefits and services that they provide society. This is particularly important where the financial values cannot easily be assessed.

The chapter also highlights that many people are unaware of their individual dependence on ES and GI within the urban setting. It was only by going through a process of identifying the ES and modelling the impact of losing these services that many of the stakeholders involved in the process realised the value of the green assets in question. Typically people take ES for granted and, as a result, the financial values calculated for ES tend to be discarded because they present a high cost for services that are considered to be free. For planning purposes, cost-benefit comparisons are more appropriate than comparing the financial value of GI with other land uses (e.g. a park versus a commercial development). In order to overcome these concerns, Mander's piece explored a possible methodology for building a human development index that acknowledges the number of people and the level of benefit they receive from a particular asset or investment. This approach, which accounts for the social impact, is also more likely to gain political support, and is easier to appreciate and act on than straight financial valuation. In addition, when prioritising green spaces a focus on services and the benefit for communities is less likely to meet opposition compared to biodiversity conservation arguments.

The methodology used to build consensus and cross-departmental appreciation of ES was presented in the eThekwini case study (Section 4.2), and provides important lessons for the GCR context. In particular, it is critical to include officials from the full range of departments not only for developing a consistent understanding of GI, but also for ensuring credibility of joint outcomes and decisions. A solutions-based discussion can be orchestrated from exploring a range of future scenarios and service-level changes, based on combined input. This type of discussion is less likely to result in apportioning blame, and instead allows stakeholders to consider and internalise alternatives without pressure or consequence. Mander stresses that developing an appreciation of the value of GI in municipalities requires champions to embed the concept into municipal processes. In addition, case studies are identified as critical for creating an evidence base that supports the GI argument.

6.2.3. Design and uptake of combined grey-green engineered solutions in the GCR

The third expert piece, written by Dunsmore from an engineering perspective, focuses primarily on the stormwater services derived from GI. In this piece, stormwater is considered to be a potential

> **"… the CityLabs were critical in shaping the focus and direction of the GAI project and building a deeper understanding of what is required to implement a green infrastructure approach in the GCR."**

breakthrough sector for the GCR within the context of an existing global evidence base and GI design standards. The piece highlights that traditional approaches to stormwater management have significant limitations, whereas evidence suggests that new approaches that include GI are increasingly important for overcoming these limitations – such as Sustainable Urban Drainage Systems (SUDS) and Water Sensitive Urban Design (WSUD). The piece identifies the significance of a GI network and that planning at a system-wide scale is necessary to maximise the impact of GI in urban areas. Similar to the traditional infrastructure approach, the value of GI is based on the whole system functioning together, not as a collection of isolated projects. Deliberate planning and designing of infrastructure with ES in mind is necessary for GI to perform effectively, and thus the piece stresses the role of spatial and strategic planning of GI, including the importance of incorporating GI into the plans of all departments.

The piece further identifies the potential for building on the existing base of green assets in the GCR and developing innovative projects that support a range of cross-departmental mandates. GI planning should start by incorporating green assets into existing municipal asset registries, which are currently designed to record only grey infrastructure assets. Including green assets in an asset registry establishes that they have value for municipalities and should help to motivate for GI networks to be protected and extended through increased investment. The asset registry would further assist with motivating for sufficient budget to maintain green assets. A fundamental risk for the rollout of GI projects is poor maintenance, which can jeopardise the long-term success and the level of services that can be derived from these investments. There is thus a strong need to establish long-term maintenance programmes in the project conceptualisation phase and ensure that sufficient operations budget is allocated to GI projects.

Dunsmore also highlighted some of the governance challenges that exist in the GCR and concluded that although the multi-functional nature of GI provides potential benefits for a range of departments, a GI approach requires commitment from and co-ordination between departments, and greater level of co-operative governance. Currently there are significant challenges related to overlapping and misaligned departmental mandates, which result in a lack of maintenance and potential system failure. In order for the GI approach to be successfully implemented, these existing challenges need to be addressed.

The author emphasised that developing and adopting design standards for GI options (in both municipal planning and the engineering sector) would speed up procurement processes and the implementation of GI projects. These standards should include various engineering, landscaping, licencing and maintenance requirements, as well as the relevant departments and processes that should be included in GI design solutions. The development of such standards and guidelines requires that an evidence base be developed through a set of case studies that quantify how various GI options perform within the GCR context. In addition, GI needs to be understood and applied by various departments, information regarding GI needs to be available in a range of forms, and it needs to be packaged in a way that speaks to the specific requirements and focuses of each relevant department.

6.3. Reflections on the GCRO's Green Infrastructure CityLab

The GI CityLab was established in January 2014, as part of the GCRO's GAI project, to provide a platform for exploring and co-producing policy relevant knowledge related to GI, and considering how GI can be mainstreamed into government thinking and planning. The structure of the GI CityLab was based on the model used by the African Centre for Cities (ACC), at the University of Cape Town, in establishing CityLabs to be a space for trans-disciplinary engagement between researchers, society and the CoCT (Anderson et al., 2013). The GI CityLab comprised a series of dialogues, held approximately every two months over the course of a year. The participants included practitioners from municipal and provincial departments, academics, and various independent stakeholders. These stakeholders' interests extend across disciplinary and sectoral boundaries including urban planning, environmental resource management, biodiversity conservation and engineering. Over the course of 2014, six GI CityLab sessions were held and were attended by between five and 17 people per session. The GI CityLab dialogues proved valuable and highlighted some of the challenges faced by cities in protecting green assets, promoting the idea of GI, and in defining key GI-related gaps that require further exploration.

Despite the success of the GI CityLab, a key challenge in the process was in identifying and securing committed participation in the CityLab from all key decision-makers from the relevant government departments and municipalities. Nevertheless, the CityLabs were critical in shaping the focus and direction of the GAI project and building a deeper understanding of what is required to implement a GI approach in the GCR. The GI CityLab dialogues provided an opportunity for the range of participating stakeholders to explore existing plans and projects, challenges and opportunities for GI, and how to collectively build the knowledge base regarding the GI in the GCR. The participants contributed a range of insights and perspectives that helped to shape the vision for a GI planning approach, in terms of the process of both gathering and informing its content. Knowledge that was revealed through the GI CityLab was explored further, sometimes with the assistance of external experts and stakeholders. Reflections from the GI CityLab are presented below and are drawn from the various sessions including those with the experts. In addition to these sessions, GCRO researchers engaged with CityLab participants individually to identify the specific challenges and opportunities in various municipalities. These individual engagements allowed for more detailed discussion and insight into the local scale implications for the GI planning approach, and are presented in Section 6.4.

The key debates and discussions that took place during the GI CityLab sessions are presented below, and include *inter alia* definitions, prioritising GI, government considerations, and the requirements for mainstreaming GI into government planning and operations.

"A fundamental risk for the rollout of GI projects is poor maintenance, which can jeopardise the long-term success and the level of services that can be derived from these investments. There is thus a strong need to establish long-term maintenance programmes in the project conceptualisation phase"

6.3.1. Defining and communicating GI

Having a well-defined goal was emphasised as a critical enabler for guiding the development of a GI approach and a united vision for GI in the GCR. Establishing a concise definition of GI also emerged as an important component of a GI approach that needs to be established before exploring how to apply a GI approach. Clear and consistent terminology should be used by all stakeholders at all scales of government to ensure that the same message is communicated and to minimise the potential for misunderstanding or miscommunication around a concept that may be unfamiliar to many stakeholders. Providing clear examples of GI should help stakeholders to recognise and understand how the term is being applied and used to inform planning.

There tends to be confusion around the GI concept as it is often misinterpreted as energy and resource efficient technology, instead of ecological systems that can provide services in a similar way to traditional infrastructure. This lack of clarity is a significant barrier to the uptake of new and unfamiliar projects. This highlights the importance of using terminology that stakeholders recognise and communicating in a way that makes sense to different stakeholders. In order to communicate effectively to a range of stakeholders, it may be necessary to package the information differently for different stakeholders. It is critical, however, that the fundamental ideas related to GI remain consistent throughout. Identifying how GI aligns with existing design and planning standards (e.g. SUDS) is a good way to encourage buy-in, as the concepts underpinning these standards should already be familiar to people. However, these design and planning standards do not always link with GI objectives, as they are not necessarily associated with ES.

6.3.2. Prioritising green infrastructure

Despite the extent of the GI network in the GCR (Chapter 2), it is not perceived to be a biodiversity rich area that provides valuable ES. Consequently, the conservation agenda does not hold much weight in urban development decisions, and thus there is a need to explore alternative approaches for emphasising the importance of ecological systems within Gauteng's urban context.

The CityLab stakeholder group noted that there are already a number of plans that identify the key biological features in the GCR that should be protected from development. Bioregional plans, for example, are

Photograph by Graeme Götz

aligned in categorising ridges, rivers and wetlands as the critical sites where ecological systems are intact, and where they should be protected. Many of the green spaces (e.g. ridges and some parks) in the GCR have not been protected through deliberate 'good' town planning practices, but instead have remained undeveloped because their topographical features pose barriers for development, such as waterlogged or unstable land.

A number of municipal departments have grappled with valuing ES in order to use these values to inform planning decisions and conservation. However, past experience has revealed that valuations are not sufficient for convincing decision-makers to preserve green assets, particularly in cases where there is an existing tension between conservation and urban development, or densification. For example, one municipal official attempted to use an ES valuation of an area to oppose the development of a business park. However, the anticipated economic benefits of the development outweighed the ES valuation. This sentiment echoes Cartwright and Oelofse's reflection that there is a "perception that environmentalists are anti-development" (page 44 of this report).

An important part of developing buy-in and changing the existing approach is by demonstrating how GI can help solve problems and not add to them. This can be done through identifying where GI objectives are directly linked with key municipal goals and development objectives. For example, there is an opportunity to pair GI with municipal densification plans, where GI can help offset the negative impacts of densification on surface runoff and the urban heat island effect. There is also potential for GI to improve the liveability of dense neighbourhoods by reducing noise, increasing privacy and providing a range of other benefits. If these benefits are linked with cost savings (e.g. reducing heating and cooling costs, or minimising stormwater infrastructure requirements), incorporating GI into densification planning could be easily justified. Another example is exploring how GI could help mitigate and adapt to climate change.

The GI approach challenges the *status quo*, and thus embedding GI into municipal planning and engineering practice is likely to be a slow and difficult process, which will require clear definitions and buy-in from the key stakeholders. To speed up the incorporation of GI into planning and engineering practice, GI approaches and principles could start being applied to existing and upcoming projects without changing the focus of the initial project aims (see Table 5.3 for examples of such projects). GI can be piloted through these projects without having to design specific GI projects from scratch. This would in turn contribute to building the case for the GI approach.

6.3.3. Building the GI case

Building a convincing case to encourage investing in GI is a key part of mainstreaming the GI approach, and relies on a robust evidence base. This evidence base can draw on both international and local case studies with the intention of building understanding and confidence in the GI approach. For example, case studies proved invaluable for building support for ecological infrastructure in the South African National Biodiversity Institute (SANBI) Grassland programme and this is also likely to prove beneficial for the GI approach in the GCR. Case studies have the potential to provide an opportunity for municipal knowledge development and information sharing. They can also provide supporting information that can minimise the risks that are taken by municipalities and can in turn increase the willingness to try an unfamiliar approach. There are also opportunities for demonstrating how GI can be mainstreamed to help ensure the longevity of built infrastructure and in so doing, reduce infrastructure capital and maintenance costs. For example, shade from trees and erosion control are two key examples of how GI can protect grey infrastructure. Case studies that demonstrate benefits such as these and indicate the return on investment in GI (e.g. job creation, cost savings, etc.) can be used as a way to motivate for budget to maintain and invest in GI.

International case studies are particularly important for applying best practice and the lessons learnt by cities that have already developed and implemented GI plans and planning approaches (see Section 2.5). A wide range of approaches and standards has been applied in different contexts around the world, and these have emerged out of various circumstances. However, building a locally-specific evidence base is also critical and existing

"International case studies are particularly important for applying best practice and the lessons learnt by cities that have already developed and implemented GI plans and planning approaches"

projects from around South Africa (e.g. uMngeni ecological infrastructure project) help to identify the particular arguments that have found traction within the South African context. A local example that emerged during the CityLab relates to the storm surge on the north coast of Durban in 2007, where the disaster impact was significantly lower in areas where the dunes and their associated ecosystems were intact. This case provides some indicative values for the importance of these ecosystems in the event of a disaster.

CityLab participants identified that a range of projects are currently underway in the GCR that could also provide useful case studies in building the local GI evidence base. These case studies need to be identified and analysed in terms of their effectiveness and the lessons that can be learnt to further the understanding and usefulness of the GI concept. Developing a comprehensive list of the relevant plans and projects currently underway in each municipality (building on Table 5.3) could be useful for building awareness of and confidence in the applicability and use of GI in the GCR. We emphasise here the need for municipal officials to be responsible for managing and guiding these case study investigations, and that each municipality should identify specific challenges and opportunities for GI, based on their existing projects. In this way a community of practice could be developed where municipalities can learn from each other and develop a wide range of locally-specific GI examples. For instance, during the CityLab, Johannesburg City Parks and Zoo (JCPZ) identified a range of possible projects related to carbon sequestration, SUDS and rooftop gardens that could prove valuable in building the GI evidence base. Emerging research from the University of the Witwatersrand highlights the suitability of green roofs to Highveld conditions (dry winters and convective summer rainfall). Their research found that in winter, when the plants die back, the soils absorb heat, providing additional warmth, whereas in summer, when the plants grow, they reduce temperatures and provide stormwater attenuation benefits. The Magaliesberg Biosphere[1] project was also identified as a key opportunity for exploring how green assets are managed at a landscape scale, instead of just at the project scale, because the biosphere area transcends municipal, provincial and ecological boundaries.

Although many international best practices are applicable to the Highveld conditions (e.g. Australian WSUD standards), some potential gaps still exist (see Chapter 5), such as:

- Catchment conditions under high dust load (particularly in informal settlement and underdeveloped areas);
- Different options for porous paving;
- Risk of increased infiltration in Granitic and Dolomitic areas;
- Establishing what local vegetation is best suited to different GI options (e.g. bioswales and green roofs); and
- Solutions to litter-related issues that cause GI system failure.

6.3.4. Cost-benefit

Evidence from South African towns and cities reveal that financial valuation has found limited purchase with politicians and financial managers (see Sections 3.2 and 6.3.2 for examples from Cape Town and Gauteng respectively). Each of the experts highlighted the limitations of relying only on valuations, and that focusing on the benefits and services provided by ecosystems may be taken more seriously than the financial valuation of green assets. Conducting

1. The Magaliesberg Biosphere has been declared as a United Nations Educational, Scientific and Cultural Organisation (UNESCO) biosphere and thus has to be managed in line with four specific functions including "conservation, sustainable development, research and monitoring, [and] training and education" (Magaliesberg Biosphere, n.d.).

cost-benefit analyses for existing green assets and potential GI projects may become an important way of building the financial case for maintaining GI and motivating for the adoption of alternative solutions. Often environmental considerations are regarded as adding complexity and additional costs to already strained municipalities. The main reason for conducting cost-benefit analyses is to reveal the true value of GI options compared to traditional grey options, using established economic principles.

A number of methods were proposed for identifying the value of the existing ES. One such method would be to compare the cost of conserving the existing GI with the cost of replacing the ES provided by the GI with built alternatives. For example, if all natural surfaces and vegetation in an area were developed over, stormwater would not infiltrate into the ground through the soil and thus the stormwater system would need to be enhanced to cope with the increased runoff volumes. In terms of investing in GI, a cost-benefit calculation would incorporate the project development costs, the maintenance costs, and the level of services that would be derived from the project. The cost of a traditional stormwater solution could then be compared with the costs associated with conserving the natural GI or the cost of developing an enhanced GI option.

Although cost-benefit analyses have the potential to make a strong case for investing in and conserving GI, there is also the potential that these analyses may not always favour the GI option. GI options need to be tailored to solve particular problems, but there will likely be cases where the traditional approach is the best way to solve the problem at hand (e.g. where available space or the underlying geology limit the viability of a GI solution). An additional consideration is that cost-benefit analyses tend to be conducted at a project scale, however, the benefits of a GI network are cumulative and thus are only truly realised when considered at the system scale. This raises concerns that unless conducted properly, cost-benefit analyses could be (and have been) used to motivate for traditional approaches over GI options. A further challenge for placing a monetary value on the services rendered by green assets is that many of the services are not generally valued in monetary terms (e.g. aesthetic and recreation), but are nonetheless important benefits of these assets. It is thus critical to build a robust and comprehensive understanding of all the benefits and implications of GI projects, particularly because the traditional approach, and associated costs and benefits are relatively well understood. There is currently research underway at the University of the Witwatersrand on developing a lifecycle costing database, which could be used as a way to cost and prioritise GI. There may be opportunities to investigate full lifecycle costing for GI compared to grey infrastructure alternatives. This may provide a robust way of evaluating the relative costs.

An additional component of the cost-benefit analysis is identifying the level of service provided by green assets and the number of people who will benefit from a particular GI project or green asset (also discussed in Chapter 4). For example, how many people will likely be affected by flooding or poor water quality in a particular area when the nearby wetland does not function properly? Another key calculation is the number of jobs that will be created through investments in various GI projects. Along with the multiple benefits of a GI planning approach, this provides a critical link between GI, jobs, services and the economy, and also reveals the multiplier effects of investing in GI.

The complexity of conducting a valuation of GI makes it unlikely for a comprehensive set of costs and benefits to be developed to suit all potential projects. It is thus critical at the start of any cost-benefit analysis to identify how the outcome of the analyses will be used to substantiate and build support for the GI approach.

"A further challenge for placing a monetary value on the services rendered by green assets is that many of the services are not generally valued in monetary terms (e.g. aesthetic and recreation), but are nonetheless important benefits of these assets."

6.3.5. Budgeting for GI projects

Financing GI projects is a critical component of implementation. However, there are currently some key barriers that limit the easy uptake of GI in municipal budgeting processes. Municipalities in Gauteng typically use operational budgets rather than capital budgets to fund the investment and maintenance of green assets. In annual budgeting processes, capital expenditure is typically apportioned greater priority than operational expenditure. Thus motivating for capital investments such as new infrastructure tends to be easier than for securing budget for the maintenance of infrastructure. Insufficient operational budget thus tends to be allocated to green assets (e.g. parks) once they have been developed. As a result these assets are allowed to degrade, which undermines their functioning and the ES that they are able to deliver.

Due to the struggle to secure sufficient operational budget, the CityLab participants raised concerns that GI projects (particularly pilot projects where there is greater uncertainty and less support) are likely to fail not because of poor design or feasibility, but because of lack of maintenance. Planning and budgeting for GI projects should therefore be based on lifecycle costs that include both capital costs and ongoing maintenance. Lifecycle costing should be the basis for comparison between green and grey infrastructure investments. This will ensure not only a fair comparison between the two alternatives, but also that sufficient budget would be allocated for the implementation and maintenance of GI.

In addition to budgeting for GI maintenance, the onerous environmental impact assessments (EIA) and water use licences required for new projects and for maintenance to be undertaken within watercourses, present barriers to the further investment in GI projects. These legal requirements add both risk and potential time delays to the project development. The burden of these approvals can be minimised, however, through including sufficient management plans in the initial project designs. The approval of the project EIA would subsequently include all maintenance, and additional approvals would not be required as long as the maintenance adhered to the original plan.

6.3.6. Asset registry

The challenges related to insufficient maintenance budget for GI projects could be addressed in part through incorporating green assets into municipal asset registries. Budgets for maintaining infrastructure are typically based on the municipal asset registry, which records each component of the infrastructure network, where each is located, its age and value. This information is used to calculate the maintenance requirements for the infrastructure network and to allocate budget accordingly.

Incorporating GI into the asset registry may not only help with securing maintenance budget, but also in planning the GI network. Traditional infrastructure is planned based on the existing assets recorded in the asset registry. Infrastructure planning typically involves a comparison between the existing infrastructure and what is needed to meet the future demand. This comparison reveals a gap between what infrastructure is in place and what is required. This allows for appropriate infrastructure to be planned and developed to fill that gap. Being able to conduct this type of analysis in the GCR, which demonstrates the value and application of GI, could prove to be a useful tool in motivating for investment into green asset networks.

Despite these potential benefits, there remain key challenges to incorporating GI into existing municipal asset registries. Municipal asset registries typically identify the existing infrastructure, but do not link the infrastructure to the service that it supplies. This is appropriate for grey infrastructure, which tends to supply only one service. GI on the other hand is multi-functional and a single asset may produce a range of services, each of which has individual value. As such, there are two possible approaches for classifying GI and for incorporating it into an asset registry. These include recording individual green assets based on the services they provide, or recording the green assets and defining the range of services that are attributed to these particular assets. Each of these approaches has its own set of challenges.

One such challenge relates to the type and level of ES provided by green assets. In contrast to traditional infrastructure that is designed according to particular engineering standards and provides the same level of service wherever it is placed, ES that

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are derived from specific green assets are dependent on their context. For example, a tree in an area with high flood risk may help to control stormwater and erosion, whereas a tree next to a main road may help to reduce noise from the traffic and to purify the air. As a result it would be difficult, if at all possible, to create a fixed set of standards that can be applied to all types of green assets in all contexts. Instead, it would be more appropriate to identify a standard methodology for allocating services and benefits to green assets, the level of service derived from these assets, and how these can be recorded in an asset registry. This methodology could then be applied to GI to meet specific urban-based service requirements.

An additional issue lies in that GI appreciates over time. Typically traditional infrastructure depreciates over time and this is captured within the asset registry to ensure that sufficient budget is set aside for replacing old infrastructure. GI, however, grows in value as it becomes more established over time, through increasing the ES that it generates. This issue could be resolved by instead of using depreciation metrics as with traditional infrastructure, applying the method that is used to capture the appreciation of land and property over time (these are also incorporated in asset registries). There remains, however, a key set of questions and potential uncertainties that need to be resolved before GI can be incorporated into municipal systems. Some of these include:

- What is the best method for capturing GI into an asset registry?
- How can the lag time in reaching full ES functioning be accounted for?
- Can the accumulated value of the GI network be factored into the value of individual assets?

CityLab participants suggested that the first step towards incorporating green assets into an asset registry is to start including green assets in municipal financial reports under the sustainability section, which is submitted to the South African Auditor General. Initially this inclusion would neither require any action nor have implications for the municipality, but as the issues presented above are resolved and appropriate financial values are derived over time, these could be allocated to the appropriate section of the financial report and asset registry, along with appropriate actions. Including green assets into municipal registries before these issues are resolved is nonetheless important for demonstrating that these assets are valuable to municipalities despite not having an accurate financial value.

6.3.7. Mapping and data

Collecting and mapping appropriate data are critical for planning purposes and to serve as a spatial inventory of green assets. This requires not only that relevant Geographic Information System (GIS) mapping layers are collected and developed, but also that the process of mapping green assets and developing a GI planning approach is guided by a clear goal or vision. This project goal and the subsequent data collection exercise should be guided by who will use the information and for what purpose. Without a clear link between the data and how it will inform decision-making and planning processes, the data collection and mapping exercise will be unable to assist GI planning processes.

The requirements that are specific to individual project goals and the end users can result in datasets that are related but not compatible due to differences in definitions and approaches guiding their respective data collection processes. For example, different municipalities across Gauteng map parks differently, with some municipalities recording them as points in the GIS dataset, and in other municipalities as polygons. In some instances open spaces (including car parks or vacant land) are classified as parks despite their differences in the services that are provided and the potential infrastructure value of parks as functional green spaces. These discrepancies can result in duplicated efforts and expenditure on data collection. In Gauteng this is partly due to a lack of awareness of what datasets and definitions are used by other departments and municipalities. CityLab participants emphasised the value of building a single centralised repository or list of existing datasets and plans for raising awareness and addressing the current discrepancies.

During the CityLab sessions, participants from the Gauteng Planning Division (GPD) highlighted that developing a set of mapping standards was part of the process towards developing the Gauteng Integrated Infrastructure Master Plan (GIIMP). This should assist with addressing some of the challenges highlighted above, as well as contributing towards the development of data that are appropriate for municipal asset registries. Particular challenges in this regard relate to setting standards for objects that have not been mapped before for government purposes, such as trees and other green assets. The definitions and standards that are developed thus need to be designed with a degree of flexibility to allow for additional elements to be included or adjusted in future. Once the standards have been developed, the existing data will need to be verified and adjusted to conform to the new guidelines.

Data collection and mapping are both costly and time-consuming. Long periods of data collection and analysis can lead to situations where data become outdated before being used to guide decisions or to implement plans. One municipal official gave the example of the bioregional plans where the data were already nearly five years old by the time the plans were approved in 2014. The more detailed the data need to be, the more expensive and time-consuming the data collection and verification processes are likely to be. It is thus important to find a balance between the level of detail and accuracy desired, and the time and resources available. This emphasises the importance of minimising any duplication in data collection across government departments, and for municipalities to draw on innovative methods for data collection.

There are many international examples of where communities have assisted in collecting data towards developing the knowledge base and monitoring natural resources. Such an example is miniSASS (mini stream assessment scoring system), where communities monitor and record water quality in streams, and upload the information onto a global database. These data have been used to inform the uMngeni ecological infrastructure project in KwaZulu-Natal, South Africa. Such initiatives require limited training, yet they can provide quite useful data. However, key obstacles of community data collection relate to the difficulty in verifying the accuracy of the collected data and to getting buy-in and commitment from the communities.

“The definitions and standards that are developed thus need to be designed with a degree of flexibility to allow for additional elements to be included or adjusted in future. Once the standards have been developed, the existing data will need to be verified and adjusted to conform to the new guidelines.”

6.3.8. Standards and planning

In addition to GIS and mapping standards, guidelines that specify GI targets for urban areas could be used for benchmarking and planning purposes. Furthermore, these may be valuable in convincing politicians to consider GI investment as an integral part of urban and infrastructure development. GI targets could include, for example, the amount of park space per number of people in an area, or a certain amount of green assets required at different levels of urban density and impermeable surface cover. Standards and guidelines would be useful for guiding planning and capital investment decisions at both the project and landscape scales.

It is, however, not possible to develop strict design templates that can be applied to all situations because GI projects need to be context-specific and thus adaptable to different requirements and environments. It is important that GI is designed so that the potential ES supplied by the proposed green assets meet the service requirements. This will depend on a robust evidence base that provides information on how different green assets function in different environments and conditions. As the understanding of GI grows, so does the scope and opportunity for pairing traditional infrastructure approaches with GI. There is already a wealth of research underway on developing innovative GI solutions for addressing urban-based problems, and identifying which plants and ecological systems are best suited to providing which services. However, a key challenge lies in mainstreaming the information regarding these alternatives.

6.3.9. Social learning

Developing the understanding and appreciation of GI through a social learning process is a critical part of informing GI planning. This is particularly important if decision-makers are to consider GI options as alternatives to traditional options. Although cost-benefit analyses may convince decision-makers of the value of GI, it is likely that more in-depth engagement with key stakeholders will be required to develop appreciation for and consensus around the value of ES. The Atlasville project, which was discussed in the CityLab, demonstrated how the roads and stormwater department was initially unsure of the proposed GI approach, but by the end of the project, when the benefits of the GI solution had become clear, the officials from the department had become strong proponents of the approach (see Section 7.2 for further detail about Atlasville).

Identifying where and how ES can deliver services at acceptable levels through engaging stakeholder participation is likely to build appreciation of the value of green assets. There are many ways that this can be done including: collaboratively identifying the green assets in a particular area; listing the associated ES and the number of people or households that benefit from these ES; and mind-mapping and modelling how different decisions affect the future potential of green assets to deliver ES compared to the *status quo*. Social learning processes such as these can be approached either at a landscape or project scale, and the particular context would dictate which one is most appropriate. A landscape scale assessment would likely provide indicative

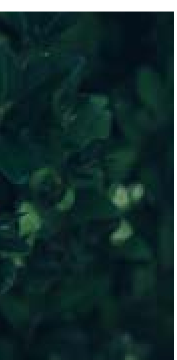
values of ES (e.g. assessing an entire river catchment), whereas the project scale assessment would include detailed analysis and cost of the ES, which can be used to undertake a detailed comparison with traditional alternatives.

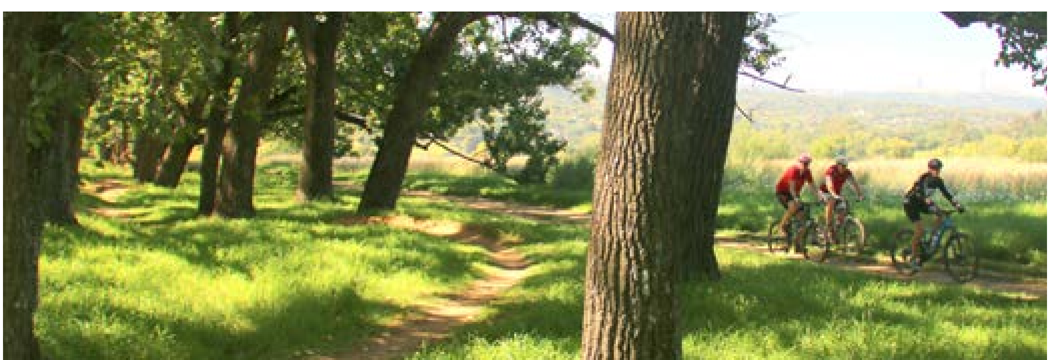
Social learning processes are likely to reveal a mismatch between the perceived and actual services from GI, which may lead to a greater appreciation of green assets. The legitimacy of collaborative social learning processes is dependent on the inclusion and input from a wide range of departments and stakeholders. Within municipalities, planners are likely to be among the first (together with environmental departments) to incorporate GI into planning. A CityLab participant highlighted that planners in municipalities have bought into the idea of conservation planning and incorporating conservation issues in the planning framework. However, there remains limited evidence that they understand how ecological systems can be incorporated into the infrastructure network and provide services in a similar way to traditional infrastructure. It is important for planners and technical stakeholders from a range of departments to gain a deepened understanding of the implications of GI for municipal planning and service delivery. Service departments (e.g. water supply, wastewater and stormwater) play a critical role in incorporating a GI approach into municipal projects and plans, and thus also need to be involved in the social learning process.

6.3.10. Co-operative governance

Building inter-departmental relationships and co-operation, as well as identifying champions to push the GI agenda, are critical for building support for GI. The current lack of co-ordination between departments is likely to be a key barrier to the uptake of GI projects. This is particularly evident where different departments are responsible for the development and maintenance of a project. For example, a stormwater management department may design and develop a series of bioswales, but the maintenance would be the responsibility of the parks department. Currently there is little co-ordination between these departments and instead of engaging other departments, departments tend to adapt projects to minimise reliance on multiple stakeholders and departments. If GI is to be incorporated into municipal projects it is necessary to change this habit. Instead, departments need to foster co-operation and involve all the relevant departments and stakeholders from as early in the project as possible – ideally from the outset.

The complexity regarding which department or entity has the responsibility for managing GI adds an additional barrier to the uptake of the GI planning approach. For example, there are uncertainties regarding the responsibility for stormwater infrastructure management in municipalities. The constitutional schedule of competencies defines managing stormwater in urban areas as a municipal responsibility. At present municipal areas cover both urban and rural areas and the constitutional definition





Photograph by Christina Culwick

has been interpreted by municipalities as referring to stormwater within built-up areas only. This creates a challenge when stormwater discharge affects rural areas downstream of built-up areas, because municipal stormwater management is disinclined to take responsibility for addressing these problems. There are also disputes in many municipalities around the maintenance of urban water courses, primarily because the responsibility for maintaining water courses shifts from the stormwater department to the parks department midway within the river channel. The stormwater department tends to be responsible for maintenance below the water line, whereas the parks department is responsible for the area above the waterline.

In addition to intra-municipal disputes, significant challenges exist in places where stormwater and flooding issues straddle municipal boundaries. These require co-ordination between the two relevant municipalities. However, collaborative solutions between municipalities are rare, which results in these issues being left either partially or completely unresolved. An example of this is in Mogale City, where flood damage has undermined municipal infrastructure and caused damage to properties along the Muldersdrif se Loop River. The catchment upstream of the flooding comprises middle to high-income residential suburbs in Mogale City, but the damage downstream affects municipal infrastructure owned by both Mogale City and the City of Johannesburg (CoJ).

In response to these and other issues, various attempts are currently underway to build stronger co-operative governance and co-ordination within and between municipalities in Gauteng. In Ekurhuleni Metropolitan Municipality (EMM) for example, a process has been started to identify departments that have potential connections with environmental projects, (e.g. where departments require EIA approval for their projects). The environmental department has started working with these departments, and agreements have been drafted that define the actions and responsibilities for achieving various environmental goals. This is a first step towards building co-operation and alignment between departments. During the CityLab sessions, municipal officials indicated that case studies could provide useful insights regarding how inter- and intra-municipal issues could be addressed. The GI planning approach should demonstrate how GI extends across traditional 'silos', and the implication this has for different departments and planning processes.

6.3.11. Community benefits and involvement

GI projects have the potential to involve communities not only in data collection (see Section 6.3.7), but also through providing opportunities for creative labour options to ensure maintenance of GI over the long-term. Maintaining GI is labour intensive, and can rely on and absorb a low-skilled, location-based workforce, particularly in areas with high unemployment and limited infrastructure (see Section 3.7). This is an important aspect of developing community and political support for GI projects. A range of potential labour options can be explored through existing work programmes, such as Jozi@Work, Expanded Public Work Programme (EPWP), and 100 days of work. The Working for Wetlands programme of the Department of Environmental Affairs (DEA) is an example of how maintaining green assets can provide job opportunities while improving the quality of green assets. Although EPWP and Working for Wetlands (the existing ecosystem-related programmes) are located primarily in rural areas, there are significant opportunities for cities to adopt similar models to create jobs that are linked with GI.

Building support from local communities is an important component in the success of GI projects. Social platforms can be used to get communities involved in monitoring and collecting data. Communities can report when maintenance is required, identify what green assets exist and potentially what services are provided or required in their area. In the case of the Atlas Spruit stormwater upgrade project, the residents highlighted a range of biodiversity concerns, which were subsequently taken under consideration by the municipality. CityLab participants identified that there is also growing evidence in Diepsloot, Johannesburg, indicating that projects with the support of the community are likely to be looked after better than those without community buy-in.

A significant portion of green assets in the GCR are privately owned, and thus a key challenge is in how private assets could be incorporated into the broader GI network, and how to encourage individuals to start thinking about their private green assets as components of the broader network. CityLab participants proposed a number of incentives that could be developed to promote the protection, maintenance and investment in GI by private individuals. For example, green assets (such as trees) could be linked with property values and rates. This could be used to incentivise individuals to retain trees and build permeable surfaces. There would also be potential to include trees in building plans once they reach a certain age, and thus permission would be required before removing them.

> **"Building support from local communities is an important component in the success of GI projects. Social platforms can be used to get communities involved in monitoring and collecting data. Communities can report when maintenance is required, identify what green assets exist and potentially what services are provided or required"**

6.4. Additional municipal and academic inputs

In addition to the commissioned expert pieces and the CityLab dialogue sessions, there have been various opportunities for GCRO researchers to engage individually with CityLab participants and other stakeholders. These engagements have provided more detailed insights into potential investigative studies and on applying the GI approach. The following insights have been extracted from the engagements with municipal and academic stakeholders.

As highlighted during the GI CityLab, the lack of maintenance budget has a significant impact on the inclination of municipalities and departments to invest in green assets. In one municipality it was highlighted that the parks department refuses to make or designate additional public parks because there is already insufficient budget to maintain their existing stock. This provides a potential barrier to the uptake of the GI approach and investing in green assets. It further highlights that green spaces are considered 'nice to have' and not as indispensable assets that provide services to urban residents. A shift in mindset is required from understanding GI in terms of assets that need to be maintained, to assets that provide services that are critical for cities.

Concerns were raised regarding the projected impact of climate change on rainfall distribution and flood characteristics. Research reveals that increased frequency of extreme rainfall events due to climate change is likely to result in flash flooding, which, if not managed and effectively planned for, may cause significant damage in urban areas (Piketh et al., 2014) outcomes from an investigation of plausible climate futures over the next century, and the potential impacts on water services including water resource management and disaster risk reduction, such as flash flooding in EMM. GI has significant potential to help address stormwater and flooding issues. Although there are many international examples of how climate change risks such as floods are being addressed through GI solutions, there are few local examples. Various officials emphasised that although it is necessary to draw on experiences and evidence from other cities and contexts (both locally and internationally), GCR-specific evidence is critical for developing an argument that is locally applicable and relevant (discussed in some detail in Chapter 5).

CoJ officials highlighted that GI case studies would be highly valuable if they were focused on low-income areas that are vulnerable to flooding, and where formal stormwater infrastructure is absent. The international evidence base does not adequately speak to the developing context, nor to some of the associated issues such as unemployment and informal settlements. The stakeholders showed significant interest in case studies which demonstrate the ability to create alternative employment options for communities through GI projects. For example, a community organisation along with academics from the University of the Witwatersrand is working to address sanitation and surface water issues in Diepsloot (also referred to in Section 6.3.11), through WSUD approaches. This community-led project comprises a range of initiatives including GI design options to address surface water issues associated with communal ablution facilities (Fitchett, 2014) This project is starting to reveal some of the challenges and opportunities for community-led GI initiatives, and could provide valuable insight for applying a GI approach in other informal settlement areas.

Participants cautioned that although there is an urgent need to build the local evidence base, pilot projects need to be chosen carefully to avoid starting a project in an area (or context) where it is likely to fail. Municipal officials highlighted the importance of aligning GI projects and case studies with existing plans and projects, particularly strategic projects such as the CoJ's Corridors of Freedom project (a strategic densification and transport plan for the City).

6.5. Conclusion

This chapter has revealed important considerations for the development of a GI planning approach in the GCR. It is clear that the traditional understanding of infrastructure and service provision needs to shift towards the inclusion of GI (both natural and cultivated) into urban planning. This requires information and guidance on what GI is, how it can be applied in the GCR, and how to adapt municipal planning and project implementation to incorporate a GI approach. This is likely to be achieved most effectively through considering the benefits and services that GI renders to society, and how investing in and maintaining green assets can provide communities with more liveable cities. Building an evidence base that demonstrates the potential and value of GI is a critical part of developing a strong argument for GI that will in turn build support for the concept and enhance investment in GI.

The GI approach is based on the understanding that green assets provide key services within urban contexts and without these assets it would be necessary to invest in traditional infrastructure. Communicating the value of GI in terms of the services they provide is likely to build support and facilitate a wider appreciation of GI than through conservation-based arguments. Packaging the GI approach and communicating it effectively are critical components for facilitating the necessary social learning process. This chapter emphasises that in order to build support for GI across the range of stakeholders, the way in which green assets are valued needs to include more than just financial values. Financial valuations need to be linked with a social learning process, which develops an appreciation of GI that is broader than strict economic values. Local case studies are important for demonstrating how GI provides an alternative option to traditional infrastructure approaches, and can assist with identifying where GI can help address key challenges facing municipalities. Demonstrating how GI can address challenges and how it can align with municipal priorities is critical for garnering support and buy-in from strategic decision-makers.

As with traditional infrastructure, planning and designing GI requires a systems approach where individual assets contribute to the benefits and services rendered by the full network. As a result, individual projects need to be considered within the whole GI network, and not planned as isolated interventions. A key challenge in valuing GI projects is that the benefits are cumulative and can only be realised at the landscape scale. The stakeholder insights highlight that a balance needs to be found between planning at a landscape scale, while ensuring that individual projects are valued and justifiable at the project scale.

Photograph by Christina Culwick

Because GI extends across departmental and municipal boundaries, collective buy-in and co-ordination for the management and maintenance of GI is necessary to ensure effective planning and implementation of a GI approach. This co-ordination is also important for addressing key barriers that are created by national and local legislation, which can prevent the implementation and maintenance of GI design solutions. Co-operative governance is beginning to develop in EMM through the establishment of inter-departmental co-operation. This, along with the lessons learned from the Atlasville flooding scheme provide examples for how municipalities can start tackling the challenges related to implementing a GI approach.

The budgeting of GI is a potential barrier to the uptake of a GI approach. This is evident in motivations for investment and maintenance budgets in GI. Although total economic valuations have proved useful in creating interest in the value of GI, evidence reveals that the values derived are incompatible with municipal finance systems and thus they have no influence on the way municipalities allocate and spend their budget. Case studies can help to build evidence for appropriate financial values that are necessary for incorporating GI into cost-benefit analyses and asset registers. Cost-benefit analyses should be able to demonstrate that GI has the potential to deliver or assist in delivering municipal services at a lower total cost, while providing additional benefits such as job creation and improved quality of life.

Incorporating green assets and their ES into municipal asset registries may be a first step in appreciating their value for cities and aligning GI projects with municipal financing structures. This in turn should assist with motivating for investment in GI through capital expenditure budgets, while securing operational budget for maintenance. Developing GI standards could provide a useful tool in assisting decision-makers and other stakeholders in benchmarking and motivating for investment and maintenance of GI. However, this potential requires further investigation.

The collection and development of sufficient and accurate spatial data, as part of a GI asset registry, plays a critical role in informing valuations of GI networks. However, existing green spatial data is not geared towards appreciating green networks, and it is necessary to explore how the existing data can be augmented and arranged to help appreciate the value of green assets and how they can be incorporated into municipal asset registries.

Through the various stakeholder inputs presented in this chapter, a range of breakthrough projects have been identified that may fast-track the uptake of the GI approach in the GCR. Identifying how GI can be used as an opportunity for job creation through community-based GI investment and maintenance programmes is likely to be critical in building political support for a GI approach. The importance of aligning GI with municipal plans and objectives was further stressed in this chapter, with particular emphasis on demonstrating how GI could help address challenges such as those resulting from densification. These breakthrough projects and strategies have been critical for guiding the next phase of the GAI project, which is presented in Chapter 7.

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7. The vision and process for applying a green infrastructure planning approach in the Gauteng City-Region

*WRITTEN BY CHRISTINA CULWICK**

7.1. Applying theoretical and stakeholder insights

This Report has established the role of green infrastructure (GI) for building a resilient urban infrastructure network and has demonstrated the potential for GI to act as an alternative and/or partner to traditional grey infrastructure. The report has further explored the principles and opportunities of applying a GI approach in the Gauteng City-Region (GCR), through considering various stakeholder insights: expert inputs, the GI CityLab dialogue sessions and insights from individual stakeholders. Each of these components plays a critical role in envisioning a GI planning approach for the GCR.

The collaborative research process that was undertaken as part of the Gauteng City-Region Observatory's (GCRO) Green Assets and Infrastructure (GAI) project has revealed key insights that straddle a range of perspectives and disciplines, and can be used to guide the next phase of research under this project. This chapter reflects on the theoretical perspectives of a GI planning approach, which were presented in Chapter 2, and the synthesised insights contained within the subsequent chapters to outline a vision for a GI planning approach that is relevant for the GCR. The chapter further identifies future work towards enabling the uptake of a GI approach in the GCR.

Based on the range of insights that have been gained in the GCRO's GAI project, it has emerged that the development of a GI planning approach will require a number of parallel processes. The following steps have been identified as important components of the upcoming phase of the GAI project:

- Building the evidence base for GI in the GCR;
- Demonstrating how GI can be applied in different contexts to address a range of urban challenges beyond environmental objectives;

* Gauteng City-Region Observatory (GCRO)

- Providing accessible and relevant information regarding GI for a diverse group of stakeholders; and
- Garnering support and buy-in for the GI approach with a wide range of stakeholders.

Building the evidence base to encourage the uptake of GI in the GCR emerged as a major focus of all stakeholder insights. As such, attention in the GAI project will be focused on establishing this through a series of investigative studies, which will contribute to the development of a GI planning approach. These studies (described in some detail in Section 7.2) will help build the argument for GI and explore some of the opportunities and challenges for applying a GI approach in municipal planning. It is particularly important that a GI approach is explored and implemented through a range of perspectives and is targeted at a range of stakeholders (e.g. politicians, planners, engineers). The role of stakeholder engagement cannot be overstated in capacitating champions who will drive changes and mainstream the GI approach within government departments. As such, an important part of shifting approaches in government planning and management is building understanding and buy-in from a range of stakeholders. Drawing on additional insights from academics and practitioners who are involved in exploring GI-related projects and approaches in South Africa can assist with developing a wider evidence base and allow for this work to be up-scaled across the GCR and the rest of South Africa. These connections may also assist with sharing the lessons learnt through similar initiatives and how these lessons can be applicable to the GCR (e.g. design standards, suggested values for green assets and ecosystem services (ES), legal frameworks).

7.2. Investigative studies

A set of four investigative studies has been formulated to address knowledge gaps based on the stakeholder input that were synthesised in Chapter 6. Conducting these case studies will constitute the next phase of the GCRO's GAI project. Their ultimate aim is to develop a case for incorporating GI into municipal planning and investment processes. Furthermore, they are designed to extend the current understanding of how to apply a GI approach in the GCR and to explore existing challenges. The four selected investigative studies are outlined below.

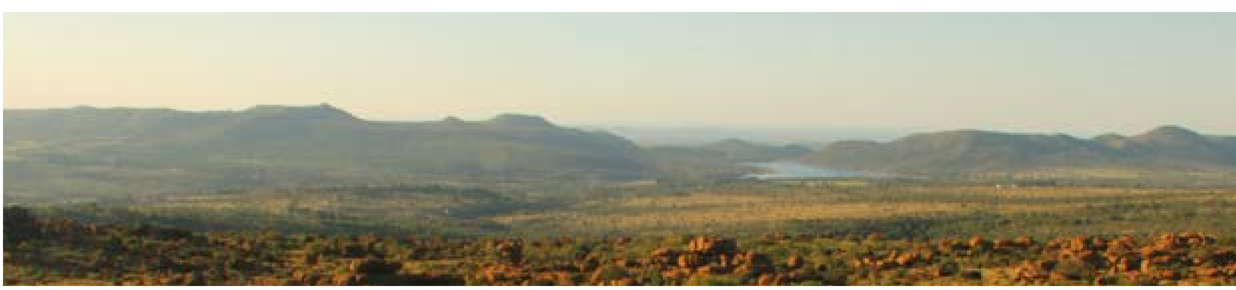
7.2.1. Green infrastructure and municipal asset registries

This study is based on the extensive debate on the need for green assets to be valued and maintained in a similar way to grey infrastructure. Based on the suggestion that this could be facilitated through incorporating green assets into municipal asset registries, the aim of this project is to identify the requirements for this process and to investigate the possible methodologies to achieve this. It is anticipated that workable pilot methods will be identified that could be scaled up in the future.

This investigative study will also explore how best to map green assets and determine which valuation exercises can be used to quantify the provision of ES by GI.

This study will include the following components:

- An investigation into how to capture and represent green assets in municipal asset registries (e.g. through a Geographic Information System (GIS) and Lidar data);



Photograph by Christina Culwick

- Explore how the ES provided by green assets can be included in an asset registry; and
- Suggest approaches for financial measurement of green assets and their associated ES.

7.2.2. Exploring surface water management options in Diepsloot

Stakeholder insights on some of the challenges and breakthrough actions for GI revealed that there is a need for projects and design solution alternatives that demonstrate how GI can be used to achieve developmental objectives for stormwater management and flood control. It was further highlighted that there is a need for the impact of GI projects to be understood at a system scale, not only at the scale of individual green assets. The aim of this project is to develop alternative stormwater management interventions for Diepsloot using GI.

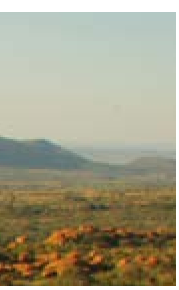
Diepsloot is a low-income settlement without a formal drainage network and limited infrastructure, located on the northern outskirts of Johannesburg. The project aims to explore whether GI can provide cost-effective infrastructure that reduces disaster risk, provides job opportunities and improves the liveability of the settlement. This project responds to a study undertaken by the City of Johannesburg (CoJ) that estimated the cost of building a traditional stormwater system in the area would be roughly R140 million (in 2010). This figure is beyond the budget available for such a project.

This investigation will explore how a range of GI alternatives can be used to address surface water problems. The investigation will be done through participatory planning approaches and will explore opportunities for mobilising capacity in local communities. This project will entail engagements with international experts, city officials, local community leaders, and local specialists in the fields of engineering.

7.2.3. Monitoring and evaluating a green infrastructure stormwater scheme in Atlasville

Stakeholder insights highlighted the importance of cost-benefit analysis and included the need for a better understanding of the maintenance requirements for various GI solutions. This study seeks to build the GI evidence base in the GCR, and to explore how a recent project that used GI to deal with flood issues compares with a grey infrastructure alternative. Particular emphasis will be placed on conducting a comparative cost-benefit analysis between the GI solution that was used and a traditional concrete alternative, including the respective maintenance requirements for each of these options.

The aim of this project is to conduct cost-benefit and lifecycle costing exercises, and present a post-project analysis of the flood relief scheme that has been implemented along the Atlas Spruit in Atlasville, a suburb in the Ekurhuleni Metropolitan Municipality (EMM). This project utilised a combined grey-green infrastructure approach to solve the area's flooding problems. Initial evaluations suggest that an alternative grey infrastructure approach (a simple concrete channel providing equivalent flood capacity) would have cost roughly R2 million more than the adopted grey-green infrastructure scheme. However, the GI option that was used has had a number of additional benefits that have not yet been accounted for. This investigation will reflect on the



> **"The aim of this project is to conduct cost-benefit and lifecycle costing exercises, and present a post-project analysis of the flood relief scheme."**

potential for this project to inform the development of other GI projects and plans in the GCR. It is anticipated that it will further demonstrate the cost saving opportunities associated with this type of GI alternative.

7.2.4. Retrofitting green infrastructure to reduce flood risk in Mogale City

This project addresses the need to demonstrate how GI can serve as a retrofitting solution for existing infrastructure to address key challenges and risks in municipalities. The aim of this project is to explore the potential for retrofitting an established residential area in Mogale City with GI solutions to help address downstream stormwater flooding issues. The site identified for this project is the upper catchment area of the Muldersdrif se Loop, above the Walter Sisulu National Botanical Gardens. This project was proposed by a municipal official from the Mogale City Local Municipality in light of significant damage downstream of the botanical gardens, which is caused by flood peaks. The extent of the flood peak (in terms of volume and velocity) has undermined infrastructure belonging to CoJ and Mogale City (electrical and sewage lines), and poses high risk to houses on the banks of the river. This project further responds to the need to establish how GI projects that extend across municipal boundaries can be co-ordinated and planned.

This project will explore how a catchment scale GI design solution could be developed to reduce the storm peak and associated downstream flood risks. Work will entail engagements with international experts, city officials, local community leaders, and local specialists in the fields of engineering, to determine how a catchment-wide GI plan could be developed.

7.3. The vision for a green infrastructure planning approach

The GI planning approach for the GCR is envisioned to be a multi-faceted approach underpinned by the necessary motivation and evidence to inform robust and meaningful infrastructure development. The multi-functional and inter-disciplinary nature of GI has been highlighted throughout this report, and the GI planning approach therefore needs to speak to these characteristics by establishing a sound case for GI from a range of perspectives and at the appropriate level of detail. In this way each stakeholder group should be able to gain maximum impact from the research (Agrawala et al., 2001). For example, on the one hand politicians need access to short, concise synthesis of the principles, which demonstrate how GI can address key objectives such as job creation and service delivery. On the other hand, stormwater engineers require access to technical detail written in a way that is appropriate for their day-to-day work. The GI planning approach is anticipated to incorporate the full range of GI options and alternatives for local and provincial planning, and provide guidance that assists decision-making regarding where a GI approach is appropriate and where it is not.

The components of a GI network need to be understood and planned for at a landscape scale, and will most likely extend across boundaries of jurisdiction (municipal and provincial). The GI planning approach offers a range of alternatives for different urban landscapes and to identify how GI can be used to address a diverse range of challenges. One such example is how GI could be used to reduce the impact of acid mine drainage and other water contamination issues in the West Rand District Municipality. Another example includes how GI could be used to counteract the negative environmental impacts of densification and its role in ensuring liveable urban areas.

7.4. Conclusion

Through this Report, the GI approach has been framed as an innovative way to address traditional infrastructure challenges in urban contexts. It has presented the principles of a GI approach and has explored examples of how cities around the world have applied these principles to address a range of urban challenges. GI plans have been used to meet a wide spectrum of objectives including climate change adaptation and mitigation, sustainable urban infrastructure, food security, water sensitive urban design, connecting people with nature, improving social cohesion, and enhancing the liveability of cities.

Frameworks for developing a GI plan have been described by authors such as Benedict and McMahon (2006) who use a stakeholder-facilitated process to inform the uptake of a GI planning approach and the development of a GI plan. However, project specifics vary depending on the scope and focus of the particular GI plan, and thus this research has highlighted the importance of developing a locally relevant GI planning approach for the GCR rather than a textbook style GI plan.

Towards building a better understanding of how to mainstream a GI planning approach into local and provincial infrastructure planning, a set of expert studies was commissioned and the GI CityLab was established. The outcomes of each of these were presented in this report, and they help to clarify the opportunities for taking up a GI planning approach in the GCR.

Based on the various stakeholder insights, a set of key considerations for the development of the GI planning approach for the GCR has been presented. A priority that emerged from the stakeholder engagement process is the need to develop an evidence base to support the uptake of a GI planning approach in the GCR. In consultation with the GI stakeholder network, the GCRO has identified four investigative studies, which will be the immediate focus of the next phase of the GAI project. These studies will investigate some of the challenges associated with the uptake of a GI planning approach and how to overcome them. The findings from these studies are expected to feed into the development of the Gauteng Integrated Infrastructure Master Plan (GIIMP) and other government planning in the GCR.

The synthesis of inputs presented in this Report has proved highly valuable in revealing critical points and perspectives in developing a GI planning approach. In the Report, the importance of a transdisciplinary approach and co-producing the knowledge required to ensure effective deployment of a GI planning approach with a range of stakeholders comes out clearly. Building up and capacitating champions within various municipalities in Gauteng is likely to be critical for successfully mainstreaming a GI approach in the GCR. Harnessing the research capacity within academia through student and other research projects, and presenting the work at local and international fora are also important components of the next phase of work. This research not only contributes towards integrated urban planning in the GCR, but also provides valuable inputs for the growing literature on applying the GI planning approach in cities across the globe.

"The synthesis of inputs presented in this Report has proved highly valuable in revealing critical points and perspectives in developing a GI planning approach ... the importance of a transdisciplinary approach and co-producing the knowledge required to ensure effective deployment of the GI planning approach with a range of stakeholders comes out clearly."

Photograph by Clive Hassal

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GAUTENG CITY-REGION OBSERVATORY

4th Floor University Corner
11 Jorissen St (Cnr Jorissen and Jan Smuts)
Braamfontein
Johannesburg
Gauteng, South Africa

tel +27 11 717 7280
email info@gcro.ac.za
www.gcro.ac.za