PLANNING FOR

GREEN INFRASTRUCTURE:

OPTIONS FOR SOUTH AFRICAN CITIES

South African Cities Network

ACKNOWLEDGEMENTS

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Editor: Ngomso Research, Writing and Editing Service
Design, Illustration and Layout: LoveBurd Design

Thanks to the property management offices at the Standard Bank and NRF buildings respectively for assisting in providing relevant data and information for the study.

Publisher: South African Cities Network ©
Date: August 2016
Place: Johannesburg
ISBN: 978-0-620-72315-2

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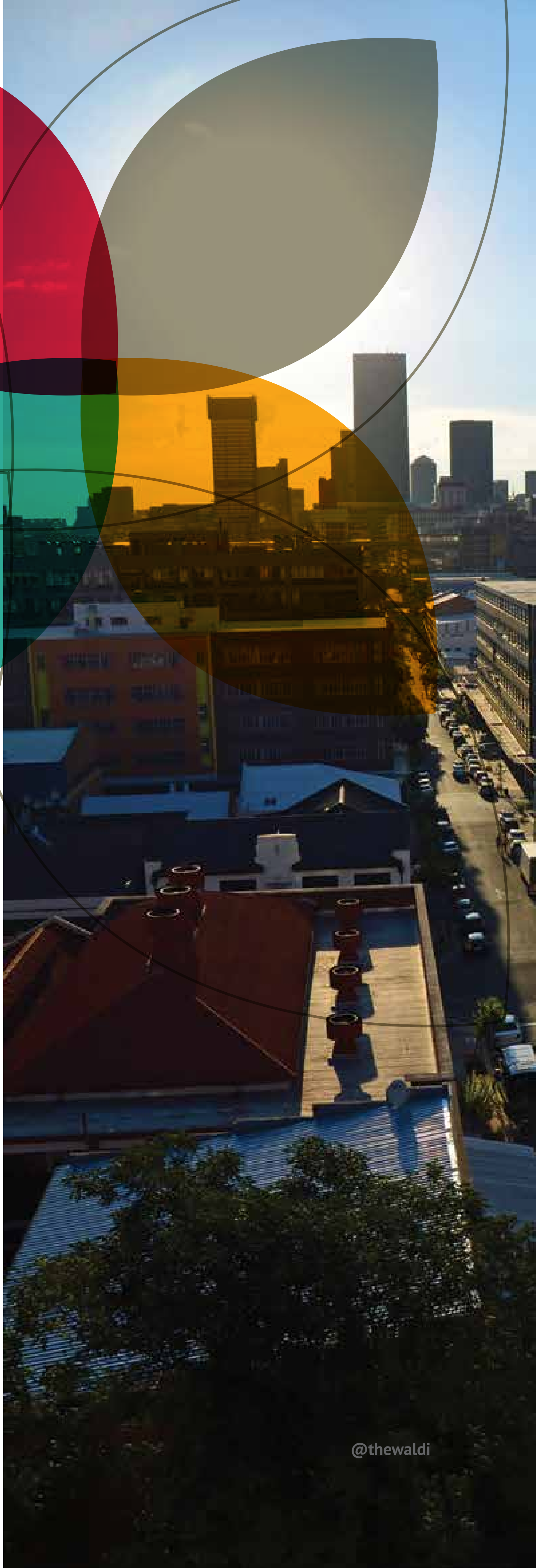

PLANNING FOR GREEN INFRASTRUCTURE

EXECUTIVE SUMMARY

The South African Cities Network promotes shared-learning partnerships between different spheres of government to support the management of South African cities. It analyses the problems facing the cities, particularly in the context of national development challenges.

This paper argues that cities need to explore ways of planning and land-use for the natural and built environment to co-exist for community benefit. To achieve this, cities may need to have discussions about intergovernmental cooperation. Such discussions can be difficult because they deal with a wide range of issues at a regional scale, across catchment areas, regional climates or broad ecological perspectives. These issues include integrative concepts of resource efficiencies, the water-energy-food nexus, integrated water resource management (IWRM) and resource decoupling. As cities are defined by relatively small administrative boundaries, it can be difficult for them to apply such (broad) concepts and approaches. South Africa's cities need to find ways of embedding sustainability into their mainstream planning, management, monitoring and evaluation.

For many years, there has been a focus on urban liveability and green infrastructure planning. It is, however, challenging to integrate spatial planning and green infrastructure, especially in city contexts where land use decision-making has to address the demand for housing and other services. In this sense, green land uses are competing against other uses and, when considering limited budgets and urban space, green land uses are often not regarded as priorities. This is also exacerbated by the apartheid legacy.

Embedding sustainability thinking into city planning means providing a multitude of services (economic, social and environmental), allocating responsibilities for managing land and monitoring the efficient consumption of resources. This paper aims to inform and encourage cities to do such, within current planning approaches and strategies. It highlights the benefits of green infrastructure (and ecosystem services) for communities and explains how green assets and ecological systems can function as part of the infrastructure that supports and sustains society and our cities.

INTRODUCTION

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“Abundant evidence suggests that the world and its constituent landscapes are on an unsustainable trajectory” (Wu, 2011). According to some commentators, sustainability has become the primary challenge and research focus of contemporary science (Mukoko, 1996). Developments in recent years have deepened the understanding of key concepts and principles of sustainability. Much work in urban studies focuses on the relationship between urban and green infrastructure planning (Casepersen, Konijnendijk & Olafsson, 2006: 7) and on the benefits thereof. Sustainability thinking has evolved to include integrative concepts such as resource efficiencies, the water-energy-food nexus, integrated water resources management (IWRM) and resource decoupling. These are generally explored at the regional scale and across broad ecological perspectives. The inclusion of green infrastructure in spatial planning approaches has been proven to increase the sustainability and resilience of cities (Tzoulas, Korpela, Venn, Yli-Pelkonen, Kazmierczak, Niemelä & James, 2007: 170, Cilliers et al., 2011a: 583; Colding, 2007: 50; Ahern et al., 2014), and as such, high up on the planning agenda.

Although the role of green infrastructure is well documented, it is difficult to integrate spatial planning approaches and green infrastructure planning in urban contexts, where land use decision-making takes place within a broad framework, driven by the demand for housing and other services. In South Africa, as in many other countries, green land uses (open areas, conservation areas, ecological sensitive areas etc., as will be captured later) are continuously competing against other urban land uses (Cilliers et al., 2011a: 695-698), and are often not prioritised due to limited budgets and human resources (Kuruneri-Chitepo & Shackleton, 2011) and inequities in terms of green space availability and the political legacy of the past (Lubbe et al., 2010: 1905; Cilliers et al., 2012a: 682). Much sustainable thinking and related theories deal with environmental processes at a regional scale; these are not always translated in a practical way to the local government level tasked with implementation.

Furthermore, cities are defined by relatively small administrative boundaries and it can therefore be difficult to apply this (sustainability and resilient) thinking beyond discussions on intergovernmental cooperation. However, environmental awareness is becoming stronger in terms of the benefits that green infrastructure can provide (Liu, Mao, Zhou, Li, Haung & Zhu, 2007: 1; Stigsdotter, 2007: 3). Implementing "green policies" is still a major challenge, especially in developing countries such as South Africa (Roberts & Diederichs, 2001; Roberts, 2008: 525; Cilliers, 2009: 617; Cilliers, 2010; Cilliers et al., 2011b), and would need to be considered and prioritized as such.

This paper deals with the importance and challenges of integrating spatial planning and green infrastructure planning within cities, and gives examples of implementation. It aims to encourage city governments to embed sustainability and resilience thinking into their planning. The paper departs from the core city planning objective of land use planning and management. The notion of open spaces and green spaces are contextualised as part of spatial planning. Green infrastructure is introduced as the infrastructure that supports and sustains society (Harrison et al., 2014:67), securing the provisioning of ecosystem services in human-dominated cities.

The paper describes a range of green infrastructure typologies as interpreted by various authors and relating to various countries; aiming to point out the complexity it presents for planning. The paper also argues for the importance and value of green infrastructure, and describes its benefits for both households and neighbourhood levels. It discusses the links between spatial planning and the green agenda, and between sustainability and resilience, focusing on issues including resource efficiencies, the water-energy-food nexus, integrated water resource management and resource decoupling. The paper further considers the current "green reality" in South Africa. It describes the city planning challenges of linking resource efficiencies and sustainability and discusses the present green infrastructure planning approach. The paper gives international and local examples of green infrastructure planning, categorized according to the broad spatial planning themes of land use, water management initiatives, social approaches, economic approaches, planning tools and the broad city vision.

The paper concludes by translating "green benefits" into spatial planning terms, and suggests ways of guiding future green infrastructure planning and management in South Africa. It deals with transforming current planning approaches, understanding the importance of green infrastructure, identifying who will benefit from green infrastructure planning, preparing the new generation and ways to plan for green(er) cities through practical planning and initiatives.

THE "GREENER" SIDE OF LAND USE PLANNING

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Land use was once considered a local issue but is now recognised as a force of global importance, as the earth's regenerative capacity can no longer keep up with demand for resources (Sustainable Cities Institute, 2012). It has never been more necessary to invest in green infrastructure and adopt dynamic, integrated and forward-thinking solutions (Landscape Institute, 2013:1). Incorporating green infrastructure into current spatial planning approaches entails multi-disciplinary collaboration and planning. Such approaches can, however, lead to misunderstanding and misinterpretation of concepts used differently or interchangeably in various disciplines (Escobedo, Kroeger & Wagner, 2011). Research by Cilliers et al. (2014a) argued this to be the case for the disciplines of Spatial Planning, Environmental Management and Urban Ecology which refer interchangeably to concepts such as green spaces, open spaces, ecosystem services (ES) and green infrastructure planning. When considering "green" land use planning and the integration of spatial planning and green infrastructure planning, it is essential that key concepts are defined, understood and consistently interpreted by all stakeholders. "Aspects that are easily definable and understood tend to get the most attention from politicians and decision-makers. If all role-players understand the concepts and positive value that good quality places contribute to areas, we are able to convincingly argue for, and attract, sufficient resources to manage and maintain spaces" (Beck, 2009:247).

In this section key concepts in city planning approaches concerned with green infrastructure provision are defined. This includes the interchangeably used concepts of open spaces, green spaces, ecosystem services, and green infrastructure. Working definitions are provided, defined by Harrison et al. (2014) as "definitions which are created and changed over time, reflecting evolving understanding or shifting orientation".

OPEN SPACE AND GREEN SPACE

In planning terms, the concepts of "open space" and "green space" are often used interchangeably as shown by "various references in official (South African) policies and databases referring to open space, and including 'developed and undeveloped green space' as part of the notion of open spaces" (Schäffler et al., 2013:3). The Consolidated Johannesburg Town Planning Scheme (City of Johannesburg, 2011), for example, refers to open spaces as "property which is under or will be under the ownership of the Council or other public authority, with or without access control, and which is set aside for the public as an open space for recreation, games, sport or cultural activity". Open space, in this sense, includes green space. James et al. (2009) distinguish between 'grey' open spaces with impermeable 'hard' surfaces, such as concrete or tarmac, and green spaces with 'soft' surfaces such as soil, grass, shrubs, trees and water.

The definition of green spaces includes spaces in a natural, undeveloped or developed (e.g. urban squares and sports fields) state that are easily accessible (Cilliers et al., 2015a: 352). According to Thaiutsa et al. (2008), green spaces are areas that have contiguous vegetated areas and spaces including artificially created city parks, stands with natural vegetation and land areas such as botanical gardens, as well as isolated street trees, street medians and private gardens. Green spaces also include school grounds and sports fields, which can be divided into formal and informal green spaces (McConnachie and Shackleton, 2010). The implication is that green spaces are predominantly natural areas, with a sense of quality and the presence of maintained facilities (Shackleton and Blair, 2013).

Green space, as referred to in this paper, and in a city planning context, includes natural (vegetated), accessible public spaces with maintained facilities that add a specific quality to communities. These qualities include social, ecological, economic, psychological, health and amenity functions (Sutton, 2006; Lange et al., 2007; Stiles, 2006) and can be translated into ecosystem services.

ECOSYSTEM SERVICES (ES) AND DISSERVICES (EDS)

In the Millennium Ecosystem Assessment (MEA, 2005) framework, there was a particular focus on ecosystem services (ES) as "a new conceptual framework for analysing and understanding the effects of environmental change on ecosystems and human well-being" (Ring et al., 2010). According to Niemelä et al. (2010), "the concept of ecosystem services is new and unfamiliar to many actors in land-use planning, although the issues contained in the concept have been included in land-use planning principles based on the objectives of sustainable development".

According to Fisher et al. (2009), ecosystem services have been defined in various ways in different disciplines ranging from ecological economics and agricultural economics to conservation biology (Escobedo et al. 2011). Costanza et al. (1997) defined ecosystem services as "ecosystem goods (such as food) and services (such as waste assimilation) representing the benefits human populations derive, directly or indirectly, from ecosystem functions". Bolund and Hunhammar (1999) provided a simpler definition, stating that "ecosystem services are the benefits supplied to humans by nature". Schäffler et al, (2013:3) defined ecosystem services as the benefits to society provided by ecosystems or ecological assets. The Millennium Ecosystem Assessment (MEA) of 2005 and The Economics of Ecosystems and Biodiversity (TEEB) of 2011 divided ecosystem services into four categories: provisioning services (such as food, medicine, water and raw materials like rubber, latex and plant oils); regulating services (such as climate regulation, air quality regulation, carbon sequestration, moderation of extreme events, water purification, erosion prevention, pollination and biological control and habitat); supporting services (for example, species diversity, habitat diversity and genetic diversity); and cultural services (such as recreation, mental and physical health, aesthetic appreciation, social cohesion, spiritual experiences and sense of place). These categories and their implementation are well documented and are part of the urban ecology literature. However, as Niemelä et al. (2010) correctly stated, they are often not "basic knowledge" for city planners and other land-use decision-makers. The provision of ecosystem services is directly linked to human well-being and thus to the well-being of cities (Cilliers and Cilliers, 2015: 1). In a city planning context, healthy ecosystems should be promoted as the foundation of sustainable cities (TEEB, 2010:1) and cities should depend on, and enhance, the natural environment (green spaces) and associated ecosystem services.

An aspect on which relatively little research has been done is ecosystem disservices (EDS). "The same natural functions and structures that provide beneficial services in urban areas are also responsible for detrimental disservices" (Von Döhren & Haase, 2015). Disservices , for example, thus refer to the damage caused to infrastructure by tree roots or falling branches; social nuisances such as allergenic pollen and poisonous plants; safety hazards from tree falls; introduction of invasive species; and the production of volatile organic compounds (VOCs) that decrease air quality (Escobedo et al., 2011; Von Döhren & Haase, 2015). When considering green infrastructure planning, the various ecosystem disservices need to be recognised and managed in their biophysical, sociological and economic contexts (Lyytimäki & Sipiä, 2009).

GREEN INFRASTRUCTURE

The concept of green infrastructure has emerged internationally as a way of understanding how green assets and ecological systems function as part of the infrastructural fabric that supports and sustains society and builds resilience (Harrison et al., 2014:67) and secure the provisioning of ecosystem services in human-dominated city landscapes (Colding, 2011).

Green infrastructure refers to the entire urban green network, including all natural, semi-natural and artificial ecological systems within, around and between urban areas and at all spatial scales (Sandström, 2002, Tzoulas et al., 2007). It is a planned and managed network of such green spaces and geographically formed corridors, aimed at conserving ecosystem values and functions and providing associated benefits to human populations (Hoctor et al., 2008:92). Green infrastructure, according to Schäffler et al. (2013) refers to an interconnected set of natural and man-made 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 building and street-level design that incorporates vegetation, such as green roofs. Such an infrastructure network can provide similar services and functions as traditional ‘hard’ (grey) infrastructure (Schäffler et al., 2013:3; Boyle et al., 2012:5). The concept of green infrastructure is often used in planning green areas to put them on a par with other infrastructure such as transport, communication, water supply, and wastewater systems (Pauleit et al., 2011). The idea of establishing strategic ecological connections in planning is not new, and was evident in Frederick Law Olmstead’s ‘parkways’ concept in the late 19th century (Hosgor & Yigiter, 2011), in early 20th century Britain in Ebenezer Howard’s Garden City movement (Asabere, 2012) and in the greenways movement of the 1990s (Kullman, 2012).

Ahern (2011: 159) stated that green infrastructure as “spatially and functionally integrated systems” is “in support of sustainability”. Articulating the ecosystem services provided by green infrastructure is thus an emerging research theme (Dobbs et al., 2011; James et al., 2009; Soares et al., 2011; Tratalos, et al., 2007; Tzoulas et al., 2007), with much of this research arguing that green infrastructure delivers measurable ecosystem services and benefits fundamental to the concept of sustainable cities (Ahern et al., 2014:255). This may be a result of the “imperative to act” and to make future urban environments more sustainable in the context of, and as a direct result of, routine urban (re)development (Ahern et al., 2014: 255).

Green infrastructure considers conservation values and actions in concert with land development, growth management and built infrastructure planning. It thus differs from conventional approaches to green space planning where conservation measures are typically undertaken in isolation from, or even in opposition to, development (Benedict & McMahon, 2002). Pro-development and pro-environmental approaches can be successfully integrated by means of green infrastructure planning. The conceptual approach of green infrastructure is strengthened, amongst other means, by its multi-functional nature, the support provided to ecosystem services, the inclusion of infrastructure that appreciates over time and its landscape-scale approach (Schäffler et al., 2013:10-13). In the city planning context, green infrastructure is “infrastructure” through its ability to deliver goods and services (Young et al., 2014: 2572). It should thus be planned for as an integral part of a city’s infrastructure and green network and not approached through ad hoc urban greening projects.


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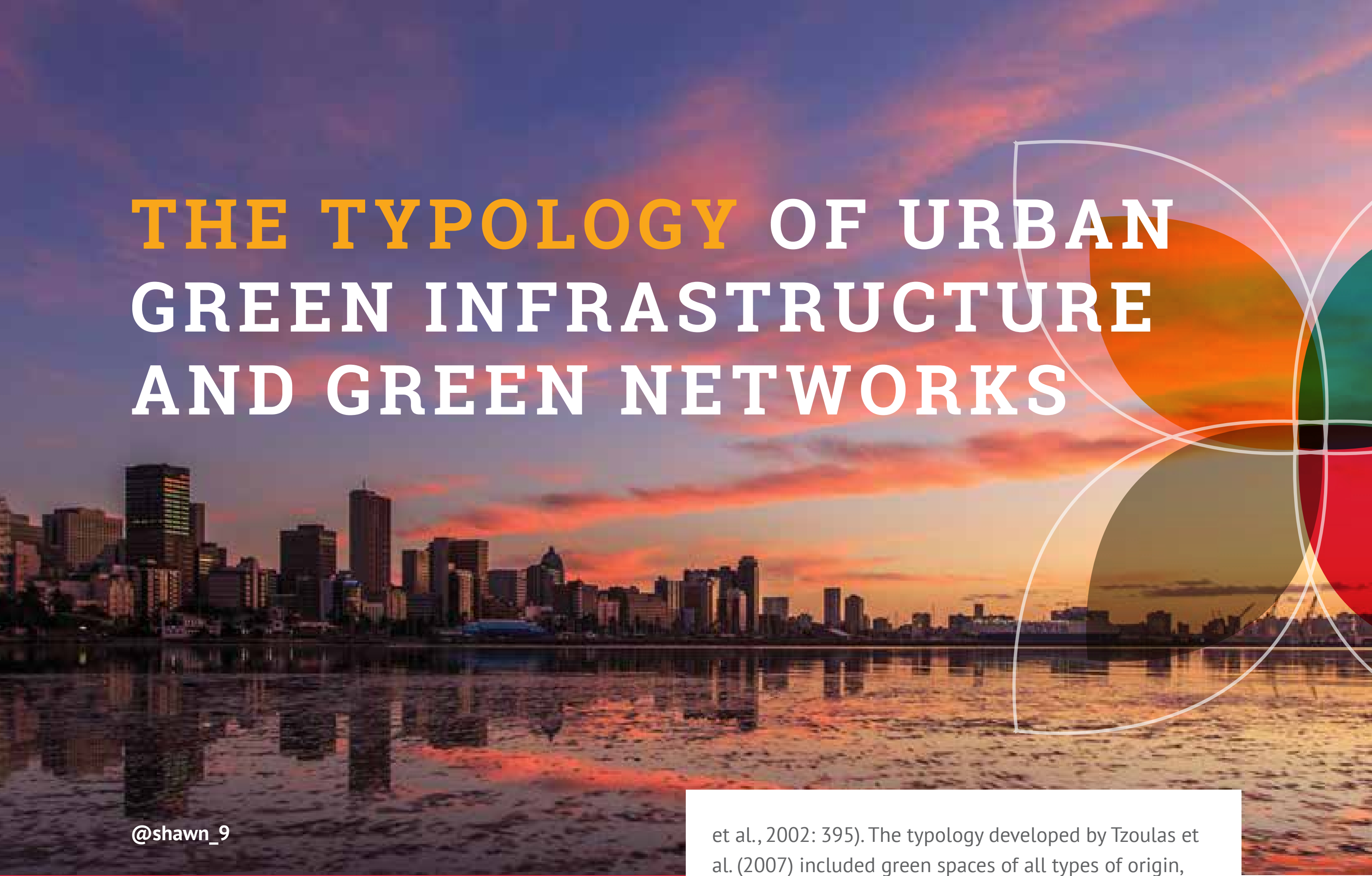
THE TYPOLOGY OF URBAN GREEN INFRASTRUCTURE AND GREEN NETWORKS



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Green infrastructure includes "public goods" (Rics, 2006) which are not only strictly "green" in terms of land use but include grey-infrastructure elements which contribute to green infrastructure in terms of ecological, economic, social, planning and multidimensional values (Van Leeuwen et al., 2009:4). This multidimensional structure and range of green infrastructure can be illustrated through the green-grey continuum (Davies et al., 2008; Cilliers and Timmermans, 2012).

Young et al. (2014: 2572) referred to researchers who have attempted to capture the range of green infrastructure in terms of green space typologies (Ahern, 1995; De Groot et al., 2002; Dunnett et al., 2002; Davies et al., 2006; Tzoulas et al., 2007; European Environment Agency (EEA), 2011; Millennium Ecosystem Assessment (MEA), 2005; Naumann et al., 2011) based on stakeholder and academic driven processes and on field research and syntheses of existing data. Ahern's research (1995) into the typology of greenways included case studies in the USA and the Netherlands, and identified the overall elements of a green infrastructure system, organised around scale, goals, landscape context and strategy. "The greenway typology presented an understanding of the similarities and variabilities amongst greenways" (Ahern, 1995:152). The typology by De Groot et al. (2002) provided "classification, description and valuation of ecosystem functions, goods and services" generated by green infrastructure. The authors divided ecosystems according to functions: regulation habitat, production and information (de Groot et al., 2002: 395). The typology developed by Tzoulas et al. (2007) included green spaces of all types of origin, ownership and function and specified green infrastructure, ecosystem functions and services, ecosystem health, socio-economic health, community health, physical health and psychological health benefits. The typology presented by Naumann et al. (2011) derived from a report to the European Commission and identified "key parameters ... to facilitate an increased understanding of differences in focus, emphasis, and characteristics between initiatives rather than to identify distinct types of categories of green infrastructure projects" (Naumann et al., 2011: 2).

Some authors included more details with regard to the specific typology and examples of such is captured in Table 1, including international perspectives (Dunnet et al., 2002; Stiles, 2006; Sutton, 2008; Scottish Government, 2011; Cvejić, 2015) and two local perspectives (provided by Schäffler (2013) and City of Tshwane (2007). The different typologies captured in Table 1, state the complexity and diversity of green infrastructure (and green spaces) and the implementation of such in spatial planning approaches (and zoning processes). Table 1 revealed that the South African green space typology is much more limited than international examples. Most South African policies and spatial planning frameworks refer only to open spaces, including variants of green space (Schäffler et al., 2013:3). Green infrastructure typologies need to be generated in order to identify opportunities to include green infrastructure within mainstream planning (Young et al., 2014:2571) and provide planners, policy makers and the public with insights into green infrastructure adoption (Young, 2014: 2574).

TYPOLOGY

TABLE 1: TYPOLOGY OF GREEN SPACES ACCORDING TO VARIOUS AUTHORS

Dunnet et al. (2002)	Davies et al. (2006)	Stiles (2006)	Sutton (2008)
International perspective			
Usage	Function-based	Function-based	Function-based
Amenity green Recreation green space (Parks, gardens, informal recreation areas, outdoor sports areas play areas), Incidental green space (Housing), Private green space (Domestic gardens). **Functional green** Productive green space (city farms, allotments), Burial grounds (Cemeteries, churchyards), Institutional grounds (School grounds and growing areas) **Semi-natural** Wetland (Open/ running water, marsh, fen), Woodland (Deciduous, coniferous and mixed woodland), Other habitats (Moor/ heath, grassland, disturbed ground). **Linear green** River and canal banks, transport corridors, other linear features e.g. cliffs.	**Agriculture and Forestry** Agriculture and fisheries, managed and unmanaged forest, natural and semi-natural green spaces, urban woodland. **Recreation** Leisure, outdoor amenity and open spaces, parks, gardens, child-spaces, holiday camps, allotments, urban farms. **Transport** Green corridors, waterways, road verges, canals **Infrastructure** Cemeteries, churchyards, burial grounds **Residential** Dwellings with domestic gardens, institution grounds **Community services** Health care services, places of worship, hospital grounds, school grounds **Previous developed land** Vacant, derelict, contaminated, land identified for development **Unused land** Rivers and streams, lakes and ponds, reservoirs, wetlands, beaches and dunes	**Public gardens** Local, neighbourhood, district, city, linear **Transport** Urban squares, plazas, pedestrian streets, other roads, corridors. car parks, cycle routes, railway lines and embankments **Residential** Private gardens, incidental residential open spaces, communal open space, children's playgrounds, roofs and balconies **Historic** Formerly private parks and gardens with historic buildings, restored or protected areas, protected view axes or corridors with historic significance **Other** Playgrounds, allotment gardens, cemeteries, sports grounds, camp sites **Water** Rivers, canals, lakes, ponds, wetlands **External** Left over agricultural land, forests, woodlands, waste disposal and excavation areas, unplanned open spaces	**Urban** Botanical gardens, undeveloped ridges, nature trails, urban squares, community gardens, local parks **Ecological** Nature reserves, bird sanctuaries, water bodies, national parks, forests, waterside areas **Agricultural** Cultivated fields, orchards and plantations **Wilderness** High mountains and cliffs, areas with extreme climate **Social** Sports facilities, recreational facilities, places of worship, zoological gardens **Prospective** Refuse sites, mine dumps, slime dams, landfill sites, mining land and quarries, canals, abandoned railway lines

TYPOLOGY

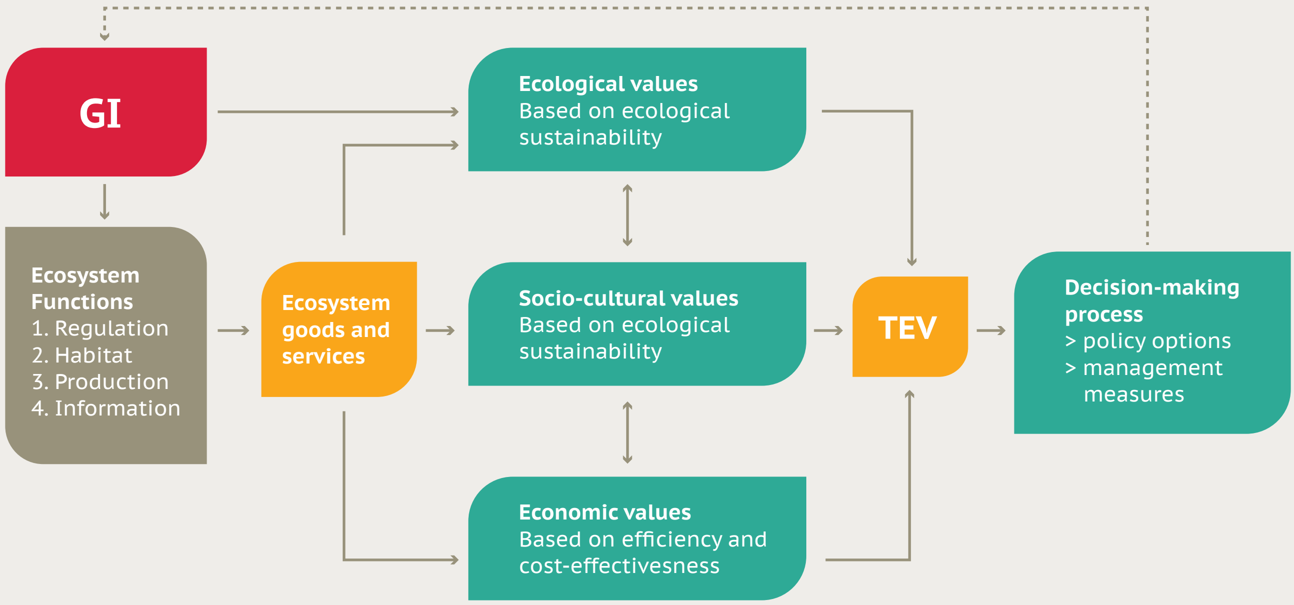
Scottish Government (2011)	Cvejić (2015) European-scale	Schäffler (2013) Gauteng	City of Tshwane (2007)
International perspective		South African perspective	
Scale-based	Provisioning services	Land Cover	Land use
Building-scale Green roofs, living walls, gardens, driveways **Street-scale** Boundary features, street trees, verges, porous paving **Neighbourhood-scale** Amenity greenspace, informal recreation spaces, play-spaces, sports areas, urban parks, cemeteries, urban woodlands, ponds **Strategic places** Civic scale spaces, public parks and gardens, green networks, forests, grasslands, designed landscapes, rivers, wetlands **Connections** Pedestrian paths, cycling routes, green links and corridors, river and canal corridors	**Building greens** Balcony green, green wall, green roof, atrium **Private, commercial, industrial, institutional** Bioswale, tree alley and street tree, hedge, street green, verge, house garden, railroad bank, green playground, school ground **Parks and recreation** Urban park, historical / botanical garden, zoological, neighbourhood green, institutional, cemetery, churchyard, green sport facility, camping area **Allotments and community gardens** Allotment, community garden **Agricultural land** Arable land, grassland, tree meadow / orchard, biofuel production / agroforestry, horticulture **Natural, semi-natural and feral areas** Forest, shrubland, abandoned and derelict area, rocks, sand dunes, sand pit, quarry, open cast min, wetland, marsh **Blue spaces** Lake, pond, river, stream, riverbed, canal, estuary, delta, sea cost	**Man-made green space:** Cultivated land (commercial agricultural, dryland, irrigated), sports and recreation, school grounds, golf courses, trees (Non-natural and planted), mines and quarries, open (parking lots) **Natural green space:** Bare rock and soil (Natural surfaces), open (little or no vegetation, bare sand), wetlands, natural grassland, forests (Indigenous), thicket, bushland, bush clumps, degraded natural vegetation	**Green network** Ecological nodes as green nodes and ridge systems as green-ways **Blue network** wetlands as blue nodes and natural watercourses as blue-ways **Grey network** cemeteries and reservoirs as grey nodes and railway lines as grey-ways **Brown network** local parks as brown nodes and urban core streets as brown ways **Red networks** Recreational space as red nodes and local boulevards as red-ways

UNDERSTANDING THE IMPORTANCE AND VALUE OF GREEN INFRASTRUCTURE

Supply and demand are both important in determining value and this is equally true when considering the value of green infrastructure (Cilliers and Timmermans, 2012; Cilliers et al., 2011a). McDonald and Marcotullio (2011) argued that green infrastructure and ecosystem services can only have economic value when they provide a service (supply) that is in demand. Value is normally quantified from an economic perspective linked to a financial value. However, to determine the value of green spaces is more complex as it cannot always be assigned a quantifiable economic value (Rics, 2004). Unlike the market for most tangible goods, the market for environmental quality does not have an observable unit price (Cilliers et al., 2015a: 353). "The fact that green-spaces are not articulated in monetary terms is one of the most important reasons for their vulnerability to urban pressures" (More et al., 1988:141; Luttik, 2000) and is often the reason why they are neglected in the planning and decision-making process (Bertaud, 2010). In order to be able to compete with other urban land uses, the value of green infrastructure needs to be identified and measured.

In recent decades, there have been increasing efforts to assign a value to green infrastructure and associated ecosystem services. The concept of total economic value (TEV) was developed in an attempt to augment the traditional evaluation of environmental goods, based on direct economic values (Cilliers and Cilliers, 2015). Total economic value includes a number of components (see Pearce, 1993; Randall and Stoll, 1983) but mainly consists of two categories: use values (direct and indirect) and non-use values (existence values, intrinsic values and legacy values) (Mayor, 2006; De Groot et al., 2010: 395-399; Gómez-Baggethun et al., 2013; Sareav, 2012: 37). Non-use value is derived from the knowledge that environmental resources continue to exist (existence value) or are available for others to use now (altruistic value) or in the future (bequest value). Use value is associated with current or future uses of a good or service (Sareav, 2012: 37). De Groot et al. (2002) created a framework which illustrated TEV in terms of functions, services and values (Figure 1).

Figure 1: Framework for assessment and valuation of green infrastructure
Source: Based on De Groot et al. (2002:394).



There is, however, no universally accepted framework for TEV (Schäffler et al., 2013:126). Some research determines the price of environmental quality by using methods such as willingness to pay, travel costs, advertising costs, direct monetary damages, the household production approach or some combination of these (Brasington and Hite 2005: 4). Other methodologies focus on the impact of land use and green infrastructure on the surroundings of properties (Irwin, 2002) and incorporate the amenity value of open (green) spaces (Brueckner et al., 1999; Turner, 2005), illustrating the importance of proximity to opportunities and amenities measured in terms of residential land prices (Goffette-Nagot et al., 2010). Other common qualitative evaluation methods include the market price method, damage cost avoided, replacement cost or substitute cost method, the contingent valuation method, the contingent choice method, the benefit transfer method, the productivity method and the hedonic pricing method (Gomez-Baggethun et al., 2013:198). The hedonic pricing method, for example, states that the price of a marketed food is related to its characteristics, or the services it provides.

These approaches and methods aim to translate value into monetary terms (Gómez-Baggethun & Pérez, 2011: 613) to emphasise green value but not to put a price tag on the environment (Turner et al., 2003: 508; Korsgaard & Schou, 2010). These methods and results are, in most cases, location specific and are an estimate (subjective valuation) of green infrastructure value (Cilliers and Cilliers, 2015). Although economic valuation methods have some shortcomings, their application may raise awareness about the importance of green infrastructure and ecosystem services for human well-being (Turner et al. 2003, Korsgaard and Schou 2010). Such research, based on the economic valuation of urban green spaces, could sensitise planners, policy makers and the general public to realise the value of these areas (Luttik, 2000; Wolf, 2004; Roberts et al., 2005; Defrancesco et al., 2006) and encourage urban administrations to embed sustainability thinking into city planning. Economic valuation of the ecosystem services provided by green infrastructure should therefore be placed in a broader decision-making context that identifies and captures its benefits (Korsgaard and Schou, 2010).

CAPTURING SPECIFIC BENEFITS OF GREEN INFRASTRUCTURE ON TWO SCALES

The close relationship between human and natural systems implies that cities cannot be sustainable or resilient until their dependence on ecosystems have been recognized (Elmqvist, 2014) and acknowledged the value of their green assets. "It is therefore necessary to start considering the importance of managing green infrastructure in urban contexts" (Elmqvist, 2014), and its benefits for city-level planning and management (Ahern, 2011). The multi-functional characteristics of ecosystems and their services are critical to understand how green assets and infrastructure can create more resilient cities (Harrison et al., 2014:56). By applying the above mentioned methods, the economic values (direct and indirect benefits) of green infrastructure can be measured. Through monetary valuation, the economic multipliers of investing in ecosystems become evident. The value derived from ecosystems in terms of the return on public investment in green infrastructure is significantly better than that of grey infrastructure (De Wit et al., 2013). There is also increasing evidence that investment in green infrastructure has cost-saving benefits for municipalities (NYC, 2007) including minimizing the cost of maintenance, stormwater management and pollution.

The design of urban green infrastructure and green spaces should be based on their potential functions and benefits (Stiles, 2006:13). The range of these benefits engage the social and economic conditions that characterise our cities and are summarized in Table 2, capturing the identified benefits of green infrastructure in terms of the economic, social and environmental benefits, on household and neighbourhood levels.

TABLE 2: GREEN INFRASTRUCTURE BENEFITS ON HOUSEHOLD AND NEIGHBOURHOOD-LEVEL.

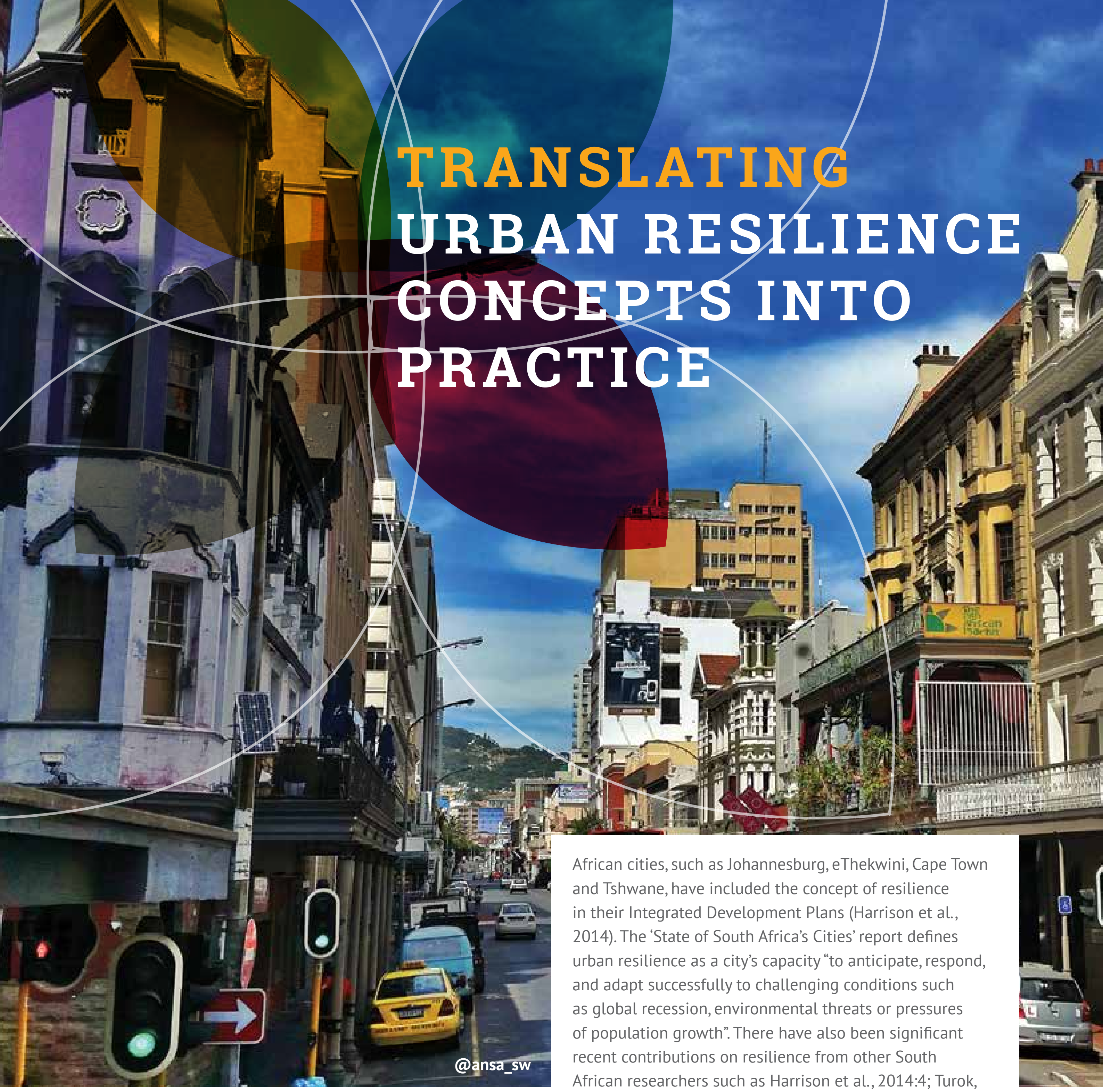
	Household-level	Neighbourhood-level
DIRECT ECONOMIC BENEFIT - FINANCIAL	Higher property prices internationally	Enhanced competitiveness of places
	Raised property prices locally	Increased market value
	Higher neighbourhood values locally	Lower stormwater costs
	Positive impact on production	Lower emissions
	Increase in economic well-being	Better marketability of areas
	Lower maintenance costs	Increased tourism spend
	Contributes to house-buyers preferences	Reduction in the cost of pollution control and prevention
		More inward investment
		Favourable image of the place
		Boost to retail sales
		Improving the legibility of the city or neighbourhood
		Multidimensional values, scientific & policy value
		Open space values
		Lower cost of artificial wetlands

INDIRECT ECONOMIC BENEFIT - SOCIAL	Household-level	Neighbourhood-level
	Enhance community cohesion	Enhance urban renewal
	Better quality living space	More social capital
	Aesthetic enjoyment	Aesthetic values and visual amenities
	Recreation opportunities	Cultural values and cultural amenities
	Leisure possibilities	Genus Loci, Identity of space
	Health benefits	Better neighbourhood relationships
	Contribute to well-being	Substitution of social value to other public spaces
	Positive perception	Enhance urban liveability
	Psychological restoration	Crucial to children's social and cognitive development
	Stress relief	Establishes a sense of place
	Positive social impact on children	
	Facilitation of social contact and communication	
	Positive assimilation of values and moral attitudes	
	Access to experiences	
	Recreational value	
INDIRECT ECONOMIC BENEFIT - ENVIRONMENTAL	Access to clean air	Greater biodiversity
	Noise reduction	More ecological functions and ecosystem services
	Enhance natural settings for play (child-friendly spaces)	Sustainable environments
	Increase intrinsic natural value	Habitat protection and provision
	Life-support value	Lower air pollution levels
	Air and water purification	Flooding alleviation, water management
	Quiet environments	Contributes to stormwater management
	Clean water and air	Improved land quality
	Rainwater retention	Lower carbon dioxide
		Climatic amelioration
		Supports water storage / supply
		Supports carbon sequestration

The values of green infrastructure, unlike grey infrastructure, appreciate over time and increase its ability to provide benefits and services. Investing in and maintaining green infrastructure can therefore lead to compounded benefits over time (Harrison et al., 2014:65) such as reducing dependence and investment in grey infrastructure (Schäffler & Swilling, 2013:248) and providing more flexibility and adaptation.

Table 2 shows that most studies examining the economic benefits of green infrastructure have been carried out in developed countries. Similar studies are needed in South Africa to investigate, and provide evidence about, the potential value of green infrastructure planning, and the implementation thereof in local context city planning processes.

TRANSLATING URBAN RESILIENCE CONCEPTS INTO PRACTICE



Spatial planning can play a central role in linking the green environment (spaces and infrastructure) with the green agenda and its associated objectives. This linkage depends on critical interventions (Wilkinson et al., 2013: 37) and innovations which need to focus on the extensive ecosystem services provided by urban green infrastructure, following an adaptive planning and design approach (Ahern, 2011; Ahern et al., 2014) as discussed in Table 2. This approach relies on the concept of urban resilience which is increasingly used locally and globally as a basis for planning and design of cities. For example, the 'State of South Africa's Cities' report developed by the South African Cities Network (SACN, 2011) was written within the context of resilient cities and several of the larger South African cities, such as Johannesburg, eThekwini, Cape Town and Tshwane, have included the concept of resilience in their Integrated Development Plans (Harrison et al., 2014). The 'State of South Africa's Cities' report defines urban resilience as a city's capacity "to anticipate, respond, and adapt successfully to challenging conditions such as global recession, environmental threats or pressures of population growth". There have also been significant recent contributions on resilience from other South African researchers such as Harrison et al., 2014:4; Turok, 2014; Swilling, 2010; Roberts et al., 2012; and Cilliers and Cilliers, 2015 (see full SACN Technical report at www.sacities.net for a comprehensive list).

Although the concepts of resilience and sustainability are complementary, they should not be used interchangeably (Elmqvist et al., in press). They are conceptually linked but are not equivalent in meaning. Sustainability is a goal for development; resilience is a way of thinking and acting that may lead towards achieving sustainability (Harrison et al., 2014:15). Walker and Salt (2006: 37) have stated that "resilience is the key to sustainability". A system is sustainable, even in the face of unpredictable change, when it has achieved a high level of resilience or adaptive capacity (Harrison et al., 2014:16).

Sustainability is a normative concept and refers to resource use and management that benefits current and future generations. However, urban sustainability is only meaningful if it takes a systems (holistic) perspective. For Childers et al. (2013), sustainability is a value-driven process that reflects societal preferences with urban resilience as its objective. A resilient city can use unsustainable practices such as relying on fossil fuel resources (Elmqvist et al., in press).

According to SACN (2011:12), there are two ways to interpret urban resilience. The first leads to a kind of adaptation that is a "defence coping mechanism focused on symptoms", such as investment in gated communities and access-controlled business parks to adapt to increased crime. The cause of the problem is not addressed and it may not create a solid basis for planning in the future. The second way "implies transforming local conditions for the better, based on experimentation, creativity and innovation." However, a number of questions arise about urban resilience. For example, what must be resilient? Ernstson et al. (2010) distinguished between resilience "in" cities (individuals or social groups on a city scale) and resilience "of" cities (broader categories of stakeholders on a bigger scale, such as a system of different cities). "There is a relationship between the two concepts but they are not the same" (Harrison et al., 2014:5). Applying resilience thinking in urban policies and plans should be carefully considered based on how resilience theories are translated from ecology to the human world to include aspects of justice and fairness, as "resilience for some, may lead to the loss of resilience for others" (Davoudi, 2012:36). Ernstson et al. (2010:531) have acknowledged this by referring to cities as "complex, adaptive political socio-ecological systems". Cities also have varying degrees of resilience and they recover at different rates from calamities (Hawley, 2014:2). To advance the resilience of a particular place, it is important to understand the reasons for differences in resilience between places (Harrison et al., 2014:5). Integrating activities such as greening open spaces through community participation may bring social, natural, economic, and physical capital into the urban sphere and make cities more resilient and adaptive to change and disturbance (Childers et al., 2013).

There are thus a number of challenges and limitations associated with implementing the concept of resilience, and Cobbinah & Darkwah (2016) argue that there is a danger in overemphasising resilience thinking. Ahern (2011) proposed five strategies for building urban resilience, namely through multi-functionality (in term of ES services), redundancy and modularisation, biodiversity and social diversity, multi-scale networks and connectivity, and adaptive planning and design. These are included in the table below.

TABLE 3: FIVE STRATEGIES FOR BUILDING URBAN RESILIENCE

Strategy	Definition	Example
Multi-functionality	Spaces are planned and developed to provide multiple ecosystem services (combining functions).	• Combining functions: football field has mainly a recreational function but also have regulating functions such as stormwater infiltration and softening the urban heat island effect. • Stacking: Vertical integration of functions, e.g. crossings for wildlife over or under roads; green roofs on office buildings; and water infiltration systems underneath parking lots. • Time-shifting: Restrict recreational use of habitat during breeding seasons of frogs, birds, other animals; less use of hydrological systems during high flow periods, or by closing certain roads at night for nocturnal animals.
Redundancy and modularisation	Redundancy refers to alternative sources that is needed for aspects such as human resources, water resources, energy supply, waste disposal and transport options, by municipalities. Urban green infrastructure is decentralized and not concentrated. It is spread over time, location and systems and therefore tends to be relatively resilient to disturbances.	• Water provision and purification, critical services provided by grey infrastructure, can be assisted by green areas in the catchment such as wetlands, riparian areas, urban forests and urban grasslands.
Diversity: biodiversity and social diversity	Diversity implies variety, with different components performing different functions, or performing the same functions differently. The higher the functional diversity (the more species fulfilling the same function), the greater the chance that these species will react differently to disturbance (response diversity). Some will not survive but others will, continuing to play their part in the ecosystem and in resilience.	• Features of urban bio-physical systems such as permeable pavements, vegetated bioswales, raingardens, green roofs and tree canopy intercepting rainfall add to the response diversity of the urban stormwater system. May reduce the amount of grey infrastructure needed for drainage and its related management costs and enhances resilience capacity.
Multi-scale networks and connectivity	The urban landscape should consist of interconnected systems, with built systems often being better connected than natural systems. Each component contributes to the functionality of the system. Urban green spaces are often fragmented which negatively impacted upon species dispersal and movement.	• Connectivity in a city should focus on blue-green networks that support biodiversity, hydrological processes, pedestrian transportation, climatic modification, neighbourhood identity and aesthetic enhancements.
Adaptive planning and design	Decision-making relating to planning and design takes place based on imperfect knowledge but with the notion to "learn by doing" through experimentation and with the realisation that the experiment may fail (the "safe to fail concept").	• Transdisciplinary adaptive design and planning framework (among relevant stakeholders)- to achieve the goal of innovation in planning and design and thus improve multiple ecosystem services. This should include experimental design guidelines, monitoring and assessment protocols and strategies to achieve specific ecosystem services. Climate adaptation has been the focus in several cities. Durban is one of the first developing country cities with adaptation plans. Adaptation plans will vary between cities, but planners should look for standardized indicators and metrics that are understandable, transferable, robust and defensible.

Source: Adapted from Ahern (2007); Ahern et al. (2011, 2014); Carmin et al. (2012); Cobbinah & Darkwah (2016); Harrison et al. (2011); Pauleit et al.(20110)

Based on Table 3, it can be concluded that there are some similarities between resilience thinking and strategic spatial planning, with each approach attempting to work with a dynamic world while acknowledging that cities are spaces of change and disturbance, which cannot always be controlled and whose developments cannot always be anticipated. The key to becoming more resilient is to be able to embrace change, a notion also held by strategic spatial planners (Balducci et al., 2011; Davoudi & Strange, 2009:37). A resilience perspective places "adaptability" at the heart of successful governance (Harrison et al., 2014:25). Green-space planning and green infrastructure planning are situated within the concepts of sustainability, as the services and benefits that green infrastructure provide are essential to enhancing quality of life and sustainable urban development (Venn and Niemela, 2004). Understanding the importance of green infrastructure, green spaces, ecosystem services and resource efficiencies underlies the possibility of sustainability and resilience within cities.

CURRENT "GREEN" REALITY IN SOUTH AFRICA

South Africa is the world's third most biologically diverse country (Wilhelm-Rechmann & Cowling, 2013: 2). Its urban landscapes are rich in biodiversity and characterised by cultural diversity but contain sharp socio-economic differences (Cilliers et al., 2014a: 260). It has a legacy of a deeply divided economic structure, embodied in racial land ownership inequalities and widespread poverty among previously disadvantaged racial groups (Cilliers et al., 2014a: 262).

South Africa has framed its response to sustainability through the National Framework for Sustainable Development (2008). Major threats to sustainability in South Africa include population growth and subsequent settlement expansion, which place pressure on landscapes and open spaces; the HIV/Aids pandemic, which increases poverty; water scarcity; safety and security issues; an energy sector dominated by coal; new, complex and unintegrated policies and strategies that can confuse stakeholders; the inefficiency of particular public service sectors; and the state's propensity to make uniformed decisions in order to meet deadlines and development quotas (Killian et al., 2005: 13-27; Cilliers et al., 2014a: 626). More than ever, authorities are confronted by these challenges and by the pressing need to make use of existing infrastructure, meet health requirements, address social concerns and deal with the impacts of climate change (Cash, 2014:126), all encapsulated in the growing housing backlog.

Addressing the needs of diverse local communities is complex, but is a high priority for municipalities in terms of budgeting and decision-making. The recent Spatial Planning and Land Use Management Act 16 of 2013 (SPLUMA) identifies municipal planning as primarily the responsibility of local governments and states that "sustainable development of land requires the integration of social, economic and environmental considerations in both forward planning and ongoing land use management to ensure that development of land serves present and future generations". SPLUMA aims to assist with effective and efficient planning and land use management (SACN, 2015:4) and local land-use planning procedures are increasingly being recognised as a strategic way for the conservation sector to influence land transformation (Wilhelm-Rechmann & Cowling, 2013: 2), particularly in relation to sections 7(b) and 7(d) which refers to "the principle of spatial sustainability" and "spatial resilience". There are however, challenges when dealing with green infrastructure planning and provision.

CHALLENGES OF CITY PLANNING LINKED TO GREEN INFRASTRUCTURE PLANNING

Despite the vision of an integrated, holistic planning process, current reality suggests that green infrastructure and green spaces are often neglected or sacrificed. This may be the result of broad regional-scale planning approaches linked to sustainability thinking which have not yet been translated to the level of local government which is tasked with implementation. The scale and rate of urban transformation poses threats, at the city level, in terms of natural resources, health conditions, safety and security, social cohesion, individual rights and increased poverty (Cohen, 2006; Du Plessis & Landman, 2002). Apart from these "normal" challenges, the South African environment has its own unique challenges in dealing with green infrastructure planning, including perceptions of "green"; decision-making structures that may lack capacity; external factors such as climate change and the rise of mega projects.

Perception of "green"

Spatial inequality greatly influences the perceived importance of and need for "green" infrastructure (Watson & Agbola, 2013). Authorities and decision-makers may tend to consider the environment to be a luxury, deserving attention and budget resources only when more pressing needs for housing and basic services have been satisfied. Balancing the importance of ensuring a sustainable future and addressing pressing current needs, is a challenge that many countries face. While the linkages between human well-being and environmental preservation are known, socio-economic pressures often take precedence. Constant conflict between land uses, conservation and development pressures (Cilliers et al., 2015a:349) results in land uses being prioritised because of their perceived value. Urban areas and developments are often prioritised because of the money value reflected in property prices, revenue from developments, higher taxes and an increased market price for land. In contrast, green infrastructure and green spaces can be perceived to have little or no monetary value (Cilliers and Timmermans, 2014), and are only considered a visual attribute and not a necessity. This lack of value assigned to green infrastructure may be the greatest reason for its under-provision and its susceptibility to land-use changes. In the context of target-driven performance and evidence-led policy-making, more concrete research is needed to capture the value of green infrastructure, and translate such into monetary values. This may contribute to reducing the green-value gap: that is, the gap between the different stakeholders (such as the Developers, Economists, Planners and Ecologists) and their understanding of the concept and benefits of "green" as interpreted by their relevant disciplines. This is a worldwide challenge associated with green infrastructure planning, as confirmed by the research of Cabe Space (2009), referring to the "information gap" which makes it difficult to maintain a strategic view, co-ordinate provision, respond to changing social needs and plan for a changing environment.

Decision-making structures

Research by Pasquini et al (2013:229) found that there is often confusion as to where the environmental management function lies, with local authorities referring matters to national or provincial departments. It therefore seems that government at local level feels itself to have limited authority on environmental affairs. Du Plessis and Landman (2002) have pointed out that many South African municipalities, with the possible exception of metropolitan municipalities, have significant capacity and skills shortages in relation to "green matters". Research by Pasquini et al. (2013:228) confirms this by illustrating the lack of understanding and knowledge of green infrastructure and ecosystem-based responses to climate change adaptation, amongst local authorities and decision-makers.

Harrison et al. (2014) drew attention to cases where resilience was incorporated into local planning practices. One instance was the City of Johannesburg (2011) which made urban resilience one of the key themes in its new Growth and Development Strategy. Another was eThekwini municipality, which submitted a successful bid to the Rockefeller Foundation for Durban to be included as one of an initial global 33 participants in a resilient cities programme. The City of Cape Town incorporated the idea of urban resilience in a number of its policies and plans including, for example, the Low Carbon Central City Strategy; and Tshwane 2055 (City of Tshwane, 2012) and Ekurhuleni 2025 (City of Ekurhuleni, 2013) refer to resilience (Harrison et al., 2014:1).

As these strategies are long term, their impact can only be measured by their Integrated Development Plans (IDPs) and annual business plans. Du Plessis' review (2014) of fifteen South African Spatial Development Frameworks (SDFs) concludes that the concept of environmental sustainability is incorporated to some extent, however, the environmental dimension is often regarded as subservient and although systematic biodiversity plans have gradually been integrated into SDFs and maps of ecosystem services developed (SANBI, 2014:11), these advances are not always unilaterally included or referred to. Du Plessis (2014:80), also found that strategic environmental assessments (SEAs) generally failed to influence or inform decision-making. More than half of the SDFs included sustainability principles but SEAs and ecologically-sensitive mapping were not applied congruently.

The South African government has made strides in updating old policies, as exemplified by the NDP, IUDF and SPLUMA. However, there remain challenges. For example, on the question of current decision-making structures and guiding policies, Pasquini et al. (2013:229) have stated that "South African municipalities are not mandated to implement mitigation or adaptation actions" despite claims that departments in all spheres of government are developing climate change plans and strategies (Ziervogel et al., 2014:606). It seems that, despite national policy and legislation such as the National Climate Change Response White Paper which inter alia promotes investment in ecosystem services (SANBI, 2014:11), limited attention to climate change filters down from the national to the local level (Pasquini et al., 2013:229). Pasquini et al. (2013:228) deduced that climate change was not a primary consideration in strategic plans at local government level and that by extension there is still a lack of green planning, in terms of developing and protecting ecosystem services. As was found in the United Kingdom (Beck, 2009:24) "there is no national evidence base to inform policy agendas relating to well-being and liveability, making it frustratingly difficult to quantify links between investment in public spaces and improvements in their quality or improvements in people's perceptions of quality of life".

Climate change interventions, related to environmental sustainability

Climate change is a major concern in South Africa as it poses threats to food security, water resources, infrastructure, health, biodiversity and ecosystem services (Ziervogel et al., 2014:606; Claes et al., 2012:15). It is expected that South Africa will in the future see longer droughts and greater damage by flooding rivers and by the sea (Killian et al., 2005:4; Ogundeji et al., 2013:112). This is especially significant given the country's extensive coastline (Retief et al., 2014:184). South Africa is also a water stressed country and water is the country's most critical natural resource (SANBI, 2014:5). Climate adaptation is increasingly being emphasised in relation to urgent socio-economic needs and threatened ecosystem services (Ziervogel et al., 2014:606) and is thus a major issue for planners (Cash et al., 2014:126). Internationally, responses to climate change take two main forms. The first, as mitigation, aim to reduce or avoid climate change impacts; the other, as adaptation, aims to cope with and manage unavoidable climate change (Laukkonen et al., 2009:288). Ecosystem-based adaptation and mitigation will become increasingly important in South Africa's responses to climate change (SANBI, 2014:6) in order to capitalise on benefits, as was indicated for Durban in South Africa (Roberts, 2010; Roberts et al., 2011; Roberts & O'Donoghue 2013). The challenge is to drastically improve the

effectiveness and cost efficiency in current infrastructure systems (Schäffler & Swilling, 2013:248) where green infrastructure may augment, but also substitute for example, existing built infrastructure, whilst simultaneously addressing objectives of climate change intervention.

Mega projects and their environmental impact

There has been discussions of a shift from the current ad hoc approach to housing development in favour of consolidation into clusters of mixed-income housing mega-projects. Internationally, mega-projects are often part of urban regeneration strategies intended to re-imagine the city, improve its attractiveness and competitiveness and promote economic growth and development (Hannan & Sutherland, 2015:205). The approach of building from scratch, encapsulated by South Africa's mega-project ethos, is given as the motivation as it may allow for efficient, simplified, innovative, well-structured and uncontested development that avoids congestion, pollution and overcrowding (Turok, 2015:4). The housing mega-projects (or new cities) envisaged for South Africa would consist of 15 to 60 000 housing units with accompanying health, educational and open (green) space provisions (Turok, 2015:9). National interest in housing mega-projects spiked in 2014 in response to escalating housing backlogs and a declining rate of housing delivery, but to date no policy framework has emerged to explain in detail the mega-project concept and its rationale (Turok, 2015;6 of 4-9). Mega-projects are often regarded as exceptions that may bypass statutory planning measures (Hannan & Sutherland, 2015:206) and even environmental planning regulations (e.g. requests for EIA exceptions). These exceptions are justified by citing the scale of the projects and time pressures, and the need for increased flexibility and efficiency in the planning and implementation phases (Follmann, 2015:214). Large scale urban developments such as mega-projects, especially when developed at high densities, may contribute to the urban heat island phenomenon, increase the likelihood of flooding and reduce urban green and tree cover (Laukkonen et al., 2009:289). The choice of location is paramount, considering urban spatial structure and access to opportunities, economic efficiency, social integration, public infrastructure costs and the impact on the environment. Most of Gauteng's proposed settlements are on the urban periphery (GCRO, 2015), with the five largest megaprojects particularly distant from the formal economy and core of the region. Furthermore, four of the five schemes also overlap with sensitive environmental areas (Turok, 2015).Where such projects are situated in ecologically sensitive areas, biological, geomorphological and hydrological impacts and environmental risks may be especially pronounced (Follmann, 2015:213). For Hannan & Sutherland (2015:211) the larger scale impact of mega-projects on the ecological integrity of the urban environment needs further research in order to account for the cumulative impacts these projects hold for economic growth and environmental degradation before they can be fully evaluated on the grounds of ecological impacts.

IMPLEMENTATION OF THE GREEN AGENDA

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This section summarizes the findings of some case studies linking green infrastructure planning with spatial planning and provides best practice examples of green infrastructure planning, resource efficiencies and sustainability. The aim is to assess practical means of embedded sustainability into city planning and minimise the green value-gap. Within adaptive planning and design, there is an "increasing recognition of the significance of network governance and context-driven approaches to urban sustainability" with "urban experiments" regarded as a way to "introduce and test new configurations for translating global imperatives in local contexts due to their potential to catalyse learning and leverage change", according to Patel (2016). The examples of experiments and initiatives described in this section deal with wide spatial planning themes of the broader city vision, planning tools, land use, water management initiatives, social approaches, and economic approaches.

BROADER CITY VISION

Eco-city planning suggests an ecological approach to urban planning and design, and conceptual thinking in environmental urban sustainability (Wong & Yuen, 2011:2). The Green City approach proposed by De Roo (2011) focuses on four scales of planning: Green Cities (which deals with key elements of the planning process and its relationship to green space); Green neighbourhoods (which examines the green spaces that form part of the wider neighbourhood and contribute to the social and catchment-scale functioning of the community); Green Streets (which introduces the role of street trees and plants, and their contribution to the effective functioning of streets in relation to air quality and the urban microclimate); and Green Buildings (which explores how the performance of buildings can be enhanced by applying green infrastructure elements such as green roofs and walls and by interior landscaping) (De Roo, 2011: 7). Hammarby-Sjöstad in

Sweden is often cited is an example where ecological planning and objectives were successfully integrated from the outset of development and resulted in a development that recycles or reuses energy, water, sewerage and waste and integrates green infrastructure and green building principles (Boyle et al., 2014:86).

Some reference to local initiatives include the Johannesburg Eco City initiative where ecological principles were adopted in urban design and renewal processes (UNEP, 2007), the integration of environmental issues in the newest Integrated Development Plan for Durban (eThekwini Municipality, 2012) and the development proposal of Verkykerskop, a small-scale agricultural town in the Free State Province, which recently received an international award from Congress for New Urbanism for creating a plan that successfully integrates sustainable agricultural and environmental management into the larger fabric of the town (DEA, 2012).

More such eco-city approaches should be encouraged within the local South African environment, incorporating conceptual thinking in environmental urban sustainability and part of urban planning approaches.

PLANNING TOOLS

The inclusion of resilience-thinking as an integral part of the governance and management of urban areas is no new phenomenon (Schäffler and Swilling 2013), nor is the increasing importance of participatory planning approaches in contemporary democratic contexts (Aylett, 2010; Pfeffer et al., 2013; Winkler, 2011; Connelly, 2010). Planning tools thus form a crucial part of successful green infrastructure planning, creating a vehicle for implementing policies, objectives and visions. Internationally, there are various examples of successful planning tools, such as the Life project launched by the European Commission in an effort to build a green infrastructure network across Europe and combat habitat fragmentation caused by grey infrastructure development (EU, 2010). Re-routing of major roads to increase the area of favourable habitats for particular species, the installation of natural green bridges to facilitate species movement (EU, 2010) and the promotion of multi-purpose land use, with the aim of harmonising wildlife interests with the economic needs of local populations, have been some of the documented successes. Concepts such as 'ecological highways' and 'migration passages' formed part of transboundary planning processes (e.g. across multiple administrative municipal boundaries), where different designs and direct cross-border infrastructure development were envisaged (EU, 2010; Schäffler et al., 2013:15). The London Green Grid tool, as another example, acknowledge green networks as a fundamental part of the city's infrastructure and the need to strategically plan and manage natural and built environments in an integrated manner. "It makes a critical contribution to the global green infrastructure discourse by explicitly recognising the value of man-made green infrastructure and the role of well-designed spaces in urban infrastructure provision" (Schäffler et al., 2013:15). The green master plan of Grand Rapids in Michigan (USA) recognizes the value of green infrastructure in addressing community challenges such as loss of park space and tree canopy, demand for walking and cycling trails and limited fresh local food sources. The master plan recommends the acquisition of added parkland in underserved suburbs, further developing the cycling network and removing limitations to community gardening (Kramer, 2014:8). The Ecological Regional Infrastructure Plan of Paris, France, is a decision-making tool for acquiring, developing and managing green spaces to ensure the inclusion of biodiversity in planning and management (Metropolis, 2011). The Go 2040 plan of Chicago (USA) commends investing in and increasing the supply of urban parks, conserving critical natural areas and establishing a network that links green spaces at regional level. Residents generally do not have sufficient access to parks and GO TO 2040 introduced regulations to distribute green open spaces more equitably (Kramer, 2014:14). The 2011 Climate Change Adaptation Plan of Copenhagen, Denmark, was presented to address potential future climate shocks even though the city is currently relatively unaffected by rising temperatures. The city has implemented initiatives to increase the number of blue and green spaces, green facades, gardens, parks and streams to regulate possible future fluctuations in temperature and reduce healthcare and energy related expenditure. The city is regarded as an early adaptor and boasts multiple green spaces that provide ecosystem services. Residents can reach a green or blue space within 10 minutes (Boyle et al., 2014:74).

Initiatives and green infrastructure planning tools are also becoming an integral part of local spatial planning approaches. The City of Durban was the first in South Africa to take this up, with the development of the Metropolitan Open Space System (MOSS) which protects the city's biodiversity and the ecosystem services it provides (Roberts et al., 2012). Several cities in South Africa have followed this example, amongst others Johannesburg (JMOSS, 2002) and Tshwane (City of Tshwane, 2005). Other initiatives and tools include the ecosystem-based adaptation (EBA) tool of Durban which includes biodiversity and ecosystem services as part of a larger strategy to assist people to adapt to the negative effects of climate change through sustainable management, conservation and restoration of ecosystems and their services (Roberts et al. 2011). The Municipal Climate Protection Programme (MCPP) in Durban is another example of key interventions designed to help with adapting to climate change. Sectoral municipal adaptation plans were piloted in three high risk sectors: water, health and disaster management. Other initiatives and projects have followed from the MCPP. They include Community Based Adaptation Plans (CAPs), the Durban Climate Change Partnership (DCCP), the Green Roof Pilot Project, Low Carbon Durban Research Project, Luganda School Water Harvesting and Micro Agricultural Water Management Technology, Buffelsdraai and Inanda Mountain Reforestation Projects, Community-Ecosystem Based Adaptation Program and integrated climate protection and biodiversity planning work-streams to focus on ecosystem based adaptation (Laros, 2012)

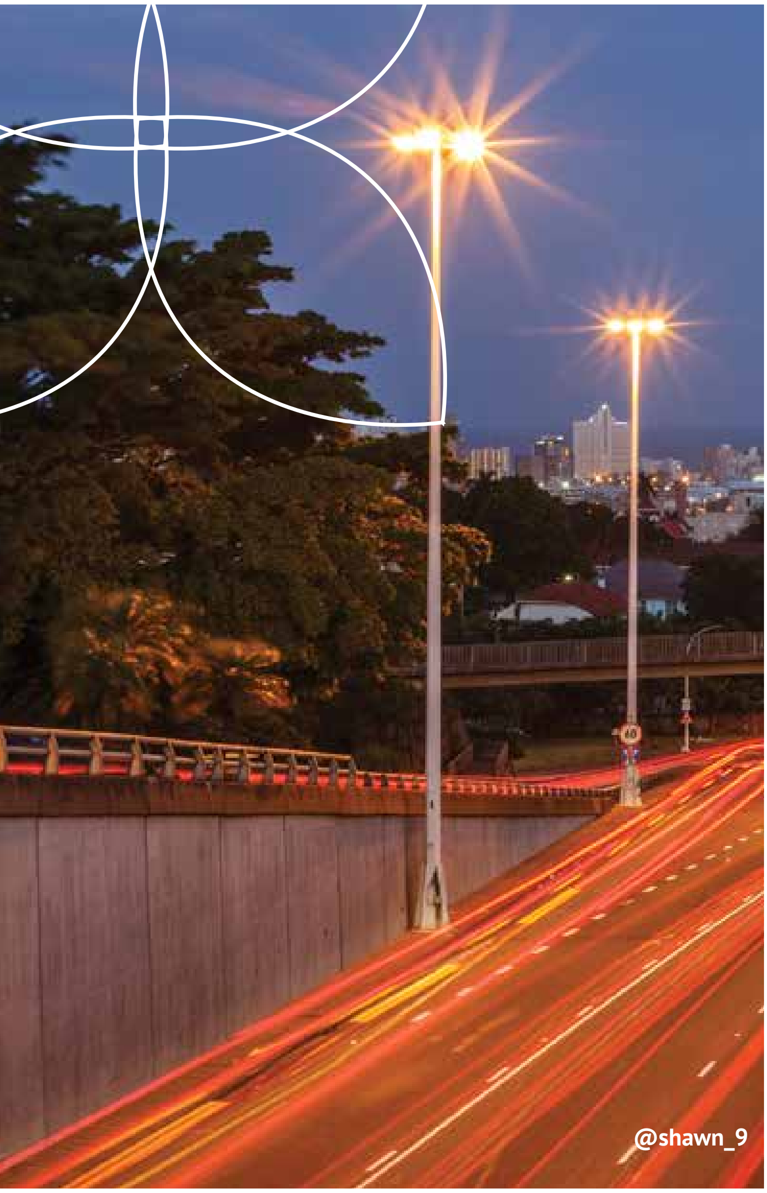

Figure 2: Aiming to become a low carbon city by installing LEDs in the city's traffic lights

The City of Tshwane's Two Parks per Ward Programme was also designed as an initiative with environmental and social spin-offs. Reducing illegal waste dumping on unmanaged land and improving human health conditions (CoT, 2012a) were among the objectives, acknowledging the social benefits of trees, parks and conservation areas and filtering them into strategic planning processes.

LAND USE

Recently there has been an increasing focus on green land-uses, especially urban greening (Donaldson-Selby et al., 2007; Shackleton et al., 2014) urban green spaces (Shackleton and Blair, 2013; Cilliers et al., 2012a; Cilliers and Cilliers, 2015; McConnachie and Shackleton, 2010; Seeliger and Turok, 2015) and environmental issues linked to land-use (Wynberg and Sowman, 2007; Todes et al., 2009; Patel, 2005). The emerald necklace vision of Los Angeles (USA) is an example of incorporating green infrastructure as an integral part of sectoral plans. The concept is to integrate green infrastructure through a loop interconnected parks and greenways. Each green space was intended to have multiple uses, such as improvements in public health, recreation, supporting biodiversity and establishing habitats, employment training, walking and cycling opportunities and reducing ambient air temperatures. One example, Lashbrook Park, was developed along an existing bike trail by constructing a bioswale filled with native and drought-tolerant plants to infiltrate stormwater (Kramer, 2014:1).

An example of a novel and innovative approach to landscape rehabilitation and urban landscape management in Mombasa, Kenya, is that of the Lafarge project in which an area of previously mined land has been rehabilitated over a 25-year period into an ecologically and economically sustainable park. This brings urban residents into contact with nature, providing social benefits and promoting education and recreation (Kithiia and Lyth 2011).

Local (green) land use initiatives are increasing in South Africa as well. The development and conservation of greenbelts and natural assets in Tshwane, especially within residential settlements, was initiated by the city's Cemeteries, Parks and Horticulture branch. The initiative largely focuses on previously disadvantaged areas including Atteridgeville, Soshanguve and Ga Rankuwa, and includes the development of nurseries for seedling production, forested nature areas, conservation areas and bird sanctuaries and the rehabilitation of wetlands and bushveld. Many of these projects are focused on school greening, with the goals of environmental education and creating environments within schools that are conducive for learners, staff and residents around the area (CoT, 2012a). Other land use initiatives included permeable paving and bio-retention ruts in the Grand Parade in Cape Town, the first major permeable paving scheme in the Western Cape (Armitage et al., 2013:4-2). Another example is the Anglican Cathedral in Pietermaritzburg that used small permeable paving as part of its re-design in 2009 (DEA, 2016). EThekwini municipality initiated a reforestation programme to transform unused landfill sites and idle land into active carbon sequestration zones. The project involves communities as 'Treepreneurs' to source seeds and grow trees for the programme (DEA, 2016).

Tree planting schemes are also being implemented in other cities in South Africa. Tree planting in itself is not considered green infrastructure planning, although it forms an important part thereof. Intensive tree-planting schemes in Johannesburg are primarily located in previously disadvantaged areas such as Soweto and Orange Farm (Schäffler et al., 2013:32). Tree-planting initiatives in Ekurhuleni Metropolitan Municipality are facilitated through Food & Trees for Africa's (FTFA) Trees for Homes programme, a public greening initiative in low-income communities. Community based educators feature strongly in the collaboration around such programmes, by assisting with tree distribution to homeowners, planting and education campaigns (Schäffler et al., 2013:74). Tree-planting initiatives in Tshwane are guided by the Cemeteries, Parks and Horticultural Services (CoT, 2012) and contribute to tree planting programmes in previously disadvantaged areas, the expansion of the urban forest and the development of the city's information and knowledge bases about its trees (CoT, 2012; Schäffler et al., 2013:85).

Figure 3: Example of urban agriculture in Johannesburg.

Figure 4: Living green roof example

The recent emphasis on green roofs is another important aspect of land use. Green roofs are roofs with vegetation placed on them in a way that is intended to provide various benefits (Scottish Government, 2011). Similar construction techniques can be applied to wall surfaces to create living walls as green facades. Various cities now strive towards greening urban roofs and walls, such as the green roofs initiative in Chicago, USA, introduced under the Chicago Climate Action Plan which initiated the development of 6000 new green roofs. Within the first two years of its implementation, 4 million square feet of green roofs were planned (Kramer, 2014:7). New water management procedures were implemented, including vegetated swales, rain gardens, permeable pavement and downspout disconnection and rainwater collection (Boyle et al., 2014:66). The live roofs of Humber River Hospital, Canada, focused on creating healthy indoor environments, reducing greenhouse gas emissions and efficient use of resources such as energy and water. The hospital has 13 192 square meters of green roofing, visible from a majority of the patient rooms and treatment areas of the hospital. The natural beauty and functions provided by the green roof contribute to the new healthcare facility's overall focus on sustainability (Greenroofs, 2015).

Various green roof initiatives have also been implemented in South Africa. These include the green roof pilot project of eThekwini Municipality, part of the Municipal Climate Protection Programme initiated in 2004 and focusing especially on the effects of climate change such as higher temperatures and increased frequency and severity of floods and droughts (Greenroofs, 2008).

The green roofs in eThekwini were created on two adjoining flat topped roofs at the Engineering Services building. They have been planted with twelve different varieties of vegetation in small, tailor-made planting trays. The aim is to monitor the growth patterns of the various vegetation types throughout the year, concentrating on the effects of extreme temperatures and the changing of the seasons (Armitage et al., 2013:10).

Figure 5: Further example of a green roof

There are also examples of green roofs in Cape Town, with a garden on the roof of the Dorp Street offices of the Western Cape Department of Environmental Affairs and Development Planning (DEADP) (Armitage et al., 2013:4-11).

WATER MANAGEMENT INITIATIVES

Studies have highlighted the importance of integrating urban planning with water catchment planning (USEPA, 2010). Green infrastructure needs to be implemented to the maximum extent feasible given the physical nature of the site, practical considerations of engineering design and reasonable consideration of financial costs and environmental impacts (Seattle Public Utilities, 2009; Tackett, 2010). The use of green infrastructure for water management can take many forms, depending on the water management requirement and available opportunities. It can be retrofitted into existing development, modified as part of a solution within an existing development or created or incorporated within new developments (Ashley et al., 2011:47)

The city of Seattle, in Washington State in the USA, is regarded a leader in the implementation of green infrastructure for innovative urban stormwater management. The city is implementing a Natural Drainage System (NDS) programme which mimics natural processes to slow stormwater runoff, increase infiltration and improve water quality. A pilot project, the Street Edge Alternative (SEA), has been highly successful in achieving the aims of the NDS and is a good example of "learning by doing". Important aspects of the SEA were narrowing streets to decrease impervious services and developing bioswales to promote stormwater infiltration. Other aspects of the project include increased planting of indigenous species, slowing of traffic in residential areas and in this way encouraging more pedestrian use and social interactions,

Figure 6: Sustainable urban drainage - Johannesburg parking lot

and raising awareness about urban stormwater issues. The project has won numerous awards and is used as a model for other cities internationally (Pauleit et al., 2011:276-278).

Similar approaches were evident in the New York combined sewer outflow systems that were captured in the Green Infrastructure Plan of 2009. Much of New York City is served by a combined sewer outflow system where rainwater and waste water flow together. The green infrastructure strategy (combined sewer outflow system) was found to be much more cost-effective. In addition, the conventional approach of expanding tanks, tunnels and water works would have no sustainability benefits beyond treating sewage and stormwater, and the upgrading of the existing system would only begin to deliver water quality benefits at the end of a decade-long design and construction period (Schäffler et al., 2013:14). Stormwater planning approaches in Vancouver, Canada, included more than 200 parks, ravines, waterfront greenways, beaches, woodland remnants, gardens, streetscapes and golf courses that in total provide about 138 000 trees, with plans to plant 2 000 trees a annum over the last 20 years. The city's urban forest is increased through uses such as food production and stormwater management. To manage stormwater runoff, the city has utilised permeable pavements, bioswales, rain gardens, and planter boxes. It also uses rain barrels, provided to residents at a subsidised price (Boyle et al., 2014:112). Rain gardens were also developed in Buffalo, New York, to provide neighbourhood parks and green space while reducing combined sewer outflow discharges (Kramer, 2014:15). Rainfall collection in Portland, Oregon, forms an integral part of the city's water management initiatives as the Tanner Springs Park collects rainfall to recreate a proportion of the wetland that once surrounded the Tanner Creek in the city's Pearl District, home to various indigenous plants (Kramer, 2014:19).

Local water management initiatives are mainly focused on stormwater management and water recycling. Stormwater infrastructure in Johannesburg is guided by the Johannesburg Roads Agency (JRA). The SWITCH action-research programme resulted in a shift from "getting rid of stormwater as quickly as possible" to "maintaining natural water balance" (SWITCH, 2010). This included innovations such as Sustainable Urban Drainage Systems (SUDS), which use integrated water cycle management through harvesting and/or treating stormwater and wastewater to supplement potable water supplies. Green infrastructure technologies that use, enhance and/or mimic the natural hydrological cycle were important in this approach (Beecham & Fallahzadeh, 2011), including small to medium-scale infrastructures such as green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, porous and permeable pavements, vegetated median strips and reforestation/re-vegetation, as well as the protection and enhancement of riparian buffers and floodplains (Schäffler et al., 2013:67). Another local water management example is that of the water recycling initiatives in Bloemfontein at the Qala Phelang Tala Canaan Project with its innovative solutions focused on domestic food production in combination with water recycling. The project is concentrated on one stand with a number of features including rain water harvesting, maize plantations and a hanging pumpkin patch to shade the patio, thus focusing at the household scale and ways to adopt greener approaches (Cleangreenfs, 2014).

SOCIAL APPROACHES

Recent research has highlighted the need for greater public involvement in urban greening and green infrastructure development (Beierle and Konisky, 1999; Wilhelm-Rechmann and Cowling, 2013; Odindi et al., 2012). The aim is to raise awareness of the importance of green infrastructure, along with its role in the city context. Social approaches that create "green" awareness need to be part of green infrastructure planning. There are various international examples of this, including the green infrastructure incentive programme of Redmond (Washington) which was developed to encourage homebuilders and developers to include green and site-scale green infrastructure strategies in new residential developments, such as retaining indigenous vegetation, reducing the impervious surface area, installing green roofs, collecting rainwater from roofs for non-potable use and recycling. These incentives include processing building permits with priority and reducing minimum stand size requirements and density revisions (Kramer, 2014:21). Other social strategies to promote the planning and implementation of green infrastructure often includes guerrilla gardening. In South Africa, this is referred to as community sponsored agriculture or 'pavement hacking', with crops of fruit and vegetables grown on pavements and in public spaces (Posthumus, 2013).

A local project to enhance green awareness amongst communities and local authorities was that of South Africa's first "green" taxi rank at Wallacedene in Cape Town where 5 000 commuters and 50 taxi drivers where provided with amenities to refresh between trips on a daily basis. A rooftop solar photovoltaic panel system was developed to generate electricity, but also enabled potable water conservation by allowing harvesting of rainwater and recycling of up to 70% of water used, supported by an underground filtering and reclamation system. In this sense the green-infrastructure and 'green design principles" delivering long-term cost savings to the City of Cape Town,

Figure 7:Nelson Mandela Bay Urban Agriculture

One example is the community food garden at the Central Methodist Mission (CMM) in Cape Town, located on Greenmarket Square. Potchefstroom's public farm movement created 10 vegetable gardens on various pavements in the summer of 2012, with the support of the local municipality and community members (Posthumus, 2013).

Another social awareness initiative is the Sandbag Houses in Freedom Park in Cape Town (South Africa) where money and resources were saved by using inexpensive local materials and local labour and thus cutting down on transportation costs. The homes were built using the EcoBeams system, which replaces brick-and-mortar with sandbags. It is reported to be a strong, safe and cheap way of providing affordable housing (FutureLagos, 2014)

The integrated design of Vissershok School, Durbanville is also creating green awareness. This school is built out of recycled shipping containers and serves as a classroom in the morning and a library in the afternoon. The large roof shelters the container from sunlight and the gap allows for ventilation and reduces heat gain. Stepped seating was included to provide space for children to eat lunch and acts as an amphitheatre for school assemblies. A green wall has been planted and once there is foliage it will act as a vegetable garden and shelter the play are from the southeast winds (FutureLagos, 2014).

Figure 8: Improving the transport system in South Africa by providing space for cycling and walking with green infrastructure

@reza_boltman

ECONOMIC APPROACHES

Various cities have created models to translate the benefits of green infrastructure into monetary values. The i-Tree STRATUM (Street Tree Resource Analysis Tool for Urban Forest Managers) developed by the US Department of Agriculture is an online tool that estimates the economic benefit generated by forests. The model quantifies aspects such as air quality improvement, energy conservation, CO2 levels, stormwater control and property values. The model is used inter alia in New York, Los Angeles and Portland to justify urban greening investments (Maco & McPherson, 2003; Symons, 2015:33). Green compensation approaches in Arnhem, Netherlands, aimed to limit green space loss within a municipality by compensating identified/determined green space loss within an area. In individual urban development projects, it is possible for green space to be lost or gained, but through green compensation there should be no overall loss on the municipal level. The ecoBUDGET concept was tested and implemented in various cities. The municipality of Växjö, Sweden, combined the ecoBUDGET with a financial accounting system to enhance environmental action and its long-term objective to become "Fossil Fuel Free". Using ecoBUDGET, Växjö has decoupled CO2 emissions from economic growth (UN-Habitat et al., 2008: 21). The city of Bologna, Italy, built ecoBUDGET indicators to use as a management and communication instrument within the city's Local Agenda 21 plan, allowing for early action and a generally more cost-effective option (UN-Habitat et al., 2008: 24). Similar approaches are gaining importance in South Africa. Natural asset protection in Midvaal Local Municipality is one example, where it is promoted as a foundation for tourism and related economic spin-offs, focusing on the natural topography and vegetation within four of the major tourism features: the Vaal Marina precinct located around the Vaal Dam, the Suikerbosrand Nature Reserve, Klip River and specifically the Henley-on-Klip area and its extensive ridges. These assets are used to expand tourism facilities in terms of mountain biking routes, hiking trails, game farming, and other adventure sports. The Midvaal EMF (2007) proposes protecting the Suikerbosrand Nature Reserve from negative external drivers of change via a one kilometre wide buffer zone of low intensity and compatible land use (Schäffler et al., 2013:104). In Cape Town, extensive calculation processes and ecosystem valuation techniques for direct and indirect use values were determined. Globally important biodiversity has been valued in terms of donor funding for conservation, and natural hazard regulation has been valued in terms of the cost of damage avoided from buffering fires, flooding and storm surge by natural assets (TEEB 2011; De Wit et al., 2013).


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CONCLUSIONS: PLACING "GREEN-BENEFITS" IN SPATIAL PLANNING TERMS

This section places the benefits and importance of green infrastructure planning in spatial planning terms. Some conclusions and recommendations are drawn to guide future planning, encourage sustainability and resilience thinking and guide city planning to resource efficiencies and sustainability.

INTRODUCING A TRANSFORMED PLANNING APPROACH

Traditional planning approaches tend to be top-down, creating master plans for entire regions and urban areas (Gehl, 2004). However, metropolitan areas have a growing need for improved connections to inter-urban green infrastructure and green areas (Timmermans et al., 2015:3) and sustainable solutions need transdisciplinary approaches. Ziervogel et al. (2014) recommend focussing on interdisciplinary research, working at multiple scales, and encouraging collaborations. The socio-ecological dimension needs to be explored, as in international research by Collins et al. (2011), Pickett et al. (2011), Ostrom (2009), WaltnerToews and Kay (2005) and Zipperer, Morse, and Gaither (2011). Cilliers et al (2014a) investigated South African interfaces between urban ecology, urban planning, and environmental management within local policy and legislation frameworks and within practice in South Africa. The research highlighted aspects of the three disciplines that could contribute to transdisciplinary planning, such as mapping and valuation of ecosystem services, strategic and integrated thinking, prediction and scenario building, governance, and decision-making and participatory planning (Cilliers et al., 2014a: 260). An integrative approach (Figure 11) was proposed as a point of departure to bridge the knowing-doing gap towards planning for sustainable green infrastructure.

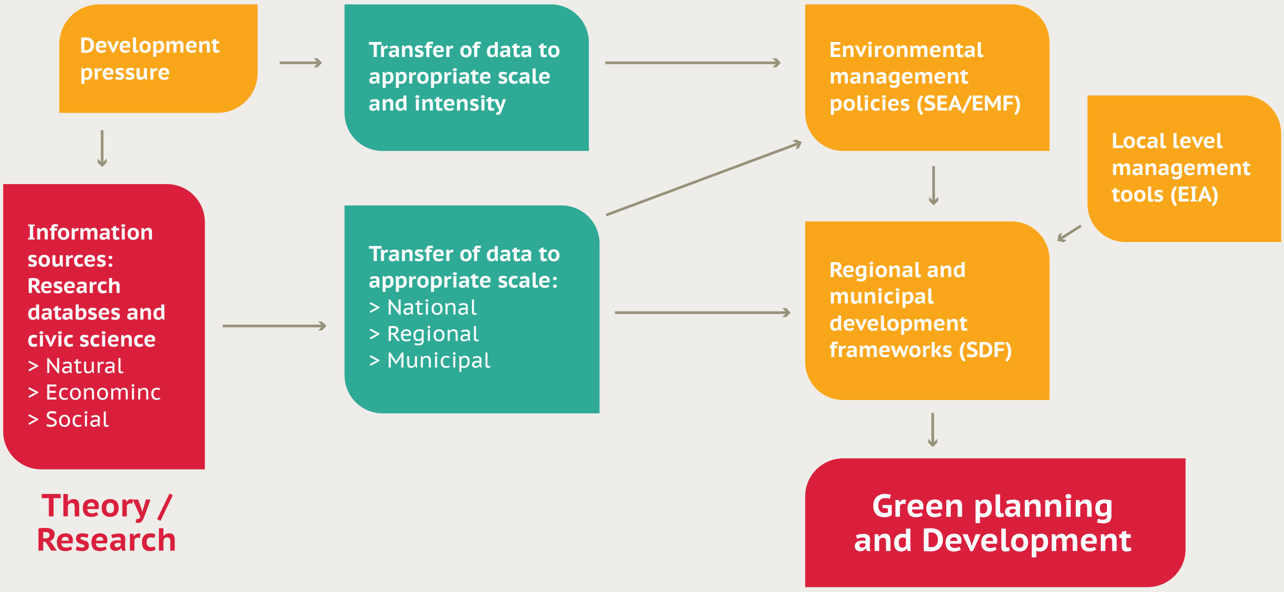


Figure 9: Integrative approach to sustainable green infrastructure planning in South Africa
Source: Cilliers et al. (2014a)

Integrative planning should be prioritised in city planning. SPLUMA now requires all municipalities to produce SDFs, instrumental in developing integrated green infrastructures across the three tiers of government. Cities which integrate the environment in spatial planning are more liveable, equitable and inviting to investors (Luttik, 2000; Defrancesco et al., 2006; Van den Berg et al., 2007; Cities Alliance, 2007).

While intergovernmental cooperation is legislated, this does not always happen in practice. Some local governments are beginning to find solutions to cooperative governance constraints. The most important lesson for municipalities, according to Walker and Salt (2006), is that they should deliberately and continually foster a way of thinking, and therefore of action, that supports proactive adaptation to change. This can be linked to the research of Ahern et al. (2014) and the proposed framework for "safe to fail" adaptive urban planning, integrating science, professional practice and stakeholder participation. The framework is transdisciplinary and includes experimental design guidelines and strategies for integrating ecosystem services in urban development, and encourages innovation in a low-risk context while assessing the achievement and performance of the intended ecosystem services (Ahern et al., 2014:254).

RECOGNIZING THE IMPORTANCE AND VALUE OF GREEN INFRASTRUCTURE

Based on sustainability thinking and the need for more resource-efficient cities, there is a need for locally applicable valuation methodologies and new approaches to understanding the potential economic benefit of green infrastructure, especially to sensitise local authorities and decision-makers and to raise awareness of the value of green urban infrastructure. Green infrastructure valuation should be included as a business cases for investing in green infrastructure (De Wit et al., 2013) in order to be able to place it in a broader decision-making context (Korsgaard & Schou, 2010). Various environmental and resource economics tools should be evaluated and customised to fit the local context. The value of green infrastructure, in terms of social-, environmental- and economic benefits, needs to be captured and interpreted into monetary terms, in order to be able to stand against the pressures of urban development (Swanwick et al., 2003). The multiple services provided by ecological assets should be emphasised, as they can maximise the delivery of services and address critical infrastructure backlogs (Harrison et al., 2014:57). This however implies data inventories of municipal green assets. Currently there is no standardised method of consolidating this information (Schäffler et al., 2013:171-172). This rationale encourages the extension and maintenance of existing green networks, and the implementation of green-grey engineered solutions (Harrison et al., 2014: 58). By effectively valuing ecosystem services, green infrastructure can be understood in the same way as grey infrastructure and similarly accounted for in municipal budgeting, planning and infrastructure asset management (Schäffler et al., 2013:171-172).

UNDERSTANDING WHO WILL BENEFIT FROM WHAT

'Scale' should be a core factor when determining the value of green spaces and ecosystem services (ES). Green infrastructure should be thought about at every stage of planning, from the strategic framework (allowing cross boundary issues to be considered) to neighbourhoods and streets to the individual house (The Scottish Government, 2011:2), and extended to regional and national scales. A negative economic impact of a green space or green commodity in terms of household-scale (measured in terms of hedonic analysis) might result in a positive economic impact in terms of neighbourhood scale (Cilliers and Cilliers, 2015). The benefits in terms of household and neighbourhood-scale should be further explored. Such an approach may imply different actors (communities, local authorities, planners, specialists) operating on various levels and influencing decision-making. The "benefit" of the green space should be related to the beneficiary (health benefits and increased property values, for instance, may be more important for communities but greater marketability and neighbourhood value and taxes may be more important to authorities). Value is subjective, but linking it to a specific scale does address some of its subjectivity. Green infrastructure planning is very site specific, and local planning decisions will be critical to tailor planning actions to the conditions in which they take place (Betancourth, 2011: 55). In addressing such issues, it should be noted that there will always be certain constraints, such as the knowledge, limited capacity, and changing needs of key local institutional players.. Many infrastructure investments and planning decisions, such as water and transportation infrastructure, and building design and urban/land-use planning, require substantial lead-time from conception and implementation. By the end of this century, investors may have to cope with climate conditions radically different from current ones. If not, they risk becoming obsolete or sustaining damage from climate change. Simply reacting to change in the short- or medium-term may result in poor investment decisions (Betancourth, 2011: 55-57). The 'sustainable future' places an increasing focus on the environment and species other than human beings (Claes, 2013:10; Imran et al., 2014, McCormick, 2013). "Perhaps we should recognise that sustainability is an ever-changing target and we can at best aspire to be more sustainable than we are at present" (Childers, 2014).

PREPARING THE NEW GENERATION

The objectives of 'the green economy' and 'urban resilience' imply new challenges and visions for current planning approaches. These, along with transdisciplinary thinking and interdisciplinary collaboration in green infrastructure planning, need to be included in training curricula for those involved, especially when considering the fine balance between protecting green spaces and developing urban spaces, and their management, as important factors in urban sustainability and resilience thinking (Cilliers et al., 2015: 352). The misinterpretation of concepts (as with the valuation and appreciation thereof), referred to as the 'value gap' (Rics, 2006; Cilliers, 2009) should be addressed through adequate education, training and professional development initiatives. Concepts such as green infrastructure, ecosystem services and disservices, resilience, sustainability, transdisciplinary planning and adaptive planning should form part of the common language of future planners.

TOWARDS A GREEN(ER) CITY

Local governments are the lead agents in responding to the sustainability crisis (Swilling, 2008). However, support and cooperation from provincial and national government are essential. "Urban environments have little national legal protection, leaving the responsibility, 'moral' obligation and initiative to municipalities to ensure that their urban environments are sustainably managed and included in planning strategies" (Du Toit & Cilliers, 2015). Green infrastructure should be thought about at every scale of planning, from the strategic framework (allowing cross boundary issues to be considered) right down through neighbourhoods and within streets to the individual house (Scottish Government, 2011:2), as illustrated in Table 4:

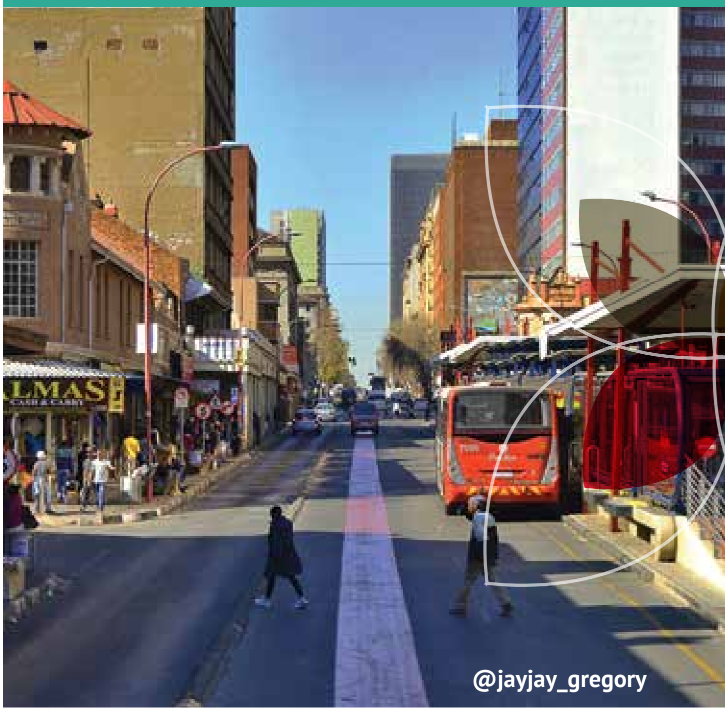


TABLE 4: LINKAGES BETWEEN GREEN INFRASTRUCTURES
Source: Scottish Government (2011)

<table>
<tr><td>The building</td><td></td><td>> Green roofs
> Living walls
> Gardens
> Driveways
> Rain gardens</td></tr>
<tr><td>Connections</td><td></td><td>> Pedestrian paths
> Cycling routes
> Green links and corridors</td></tr>
<tr><td>The street</td><td></td><td>> Boundary features
> Street trees
> Verges
> Paving
> Rain gardens
> Bioswales</td></tr>
</table>

Connections

> Pedestrian paths
> Cycling routes
> Green links and corridors

Neighbourhood

> Amenity greenspace
> Recreation space
> Urban parks
> Cemeteries
> Woodlands
> Ponds

Connections

> Pedestrian paths
> Cycling routes
> Green links and corridors
> River and canal corridors

Strategic places

> Civic spaces
> Public parks
> Green networks
> Forests, gardens
> Grasslands
> Rivers, wetlands

Green infrastructure could be considered on a household-level by incorporating construction techniques to include green roofs, green wall surfaces and rain gardens. On the street level, it should form part of street design. On the neighbourhood level, it should be considered how existing roads, paths and surrounding developments can be integrated. Masterplans should ultimately knit developments into the wider green network (Scottish Government, 2011). Green infrastructure planning can be used to strive towards urban resilience (Harrison et al., 2014:57), as from a strategic perspective green infrastructure offers a unique opportunity for adaptive planning and design through natural resource management (Ahern, 2011). This however requires a shift in thinking, incorporating multifunctional services of green infrastructure planning and integrating them with grey infrastructure to release multiple benefits of various dimensions (social, environmental and economic). This implies, as stated by Giordano (2013:4), considering green infrastructure features as greening principles in the planning process (Figure 2). The move towards green(er) infrastructure include a wide range of greening levels, from the plug-in of a green component on traditional infrastructure (such as filters on industrial equipment, and solar water heaters on roof tops) to the provision of traditional services through changes in infrastructure building practices (such as insulated housing and green roads), greening these services (such as addressing mobility requirements) and including ecological infrastructure (such as natural or artificial wetlands instead of sewage plants) (Giordano, 2013:4) within mainstream planning. Such a greening spectrum should be considered as part of the green infrastructure planning process.

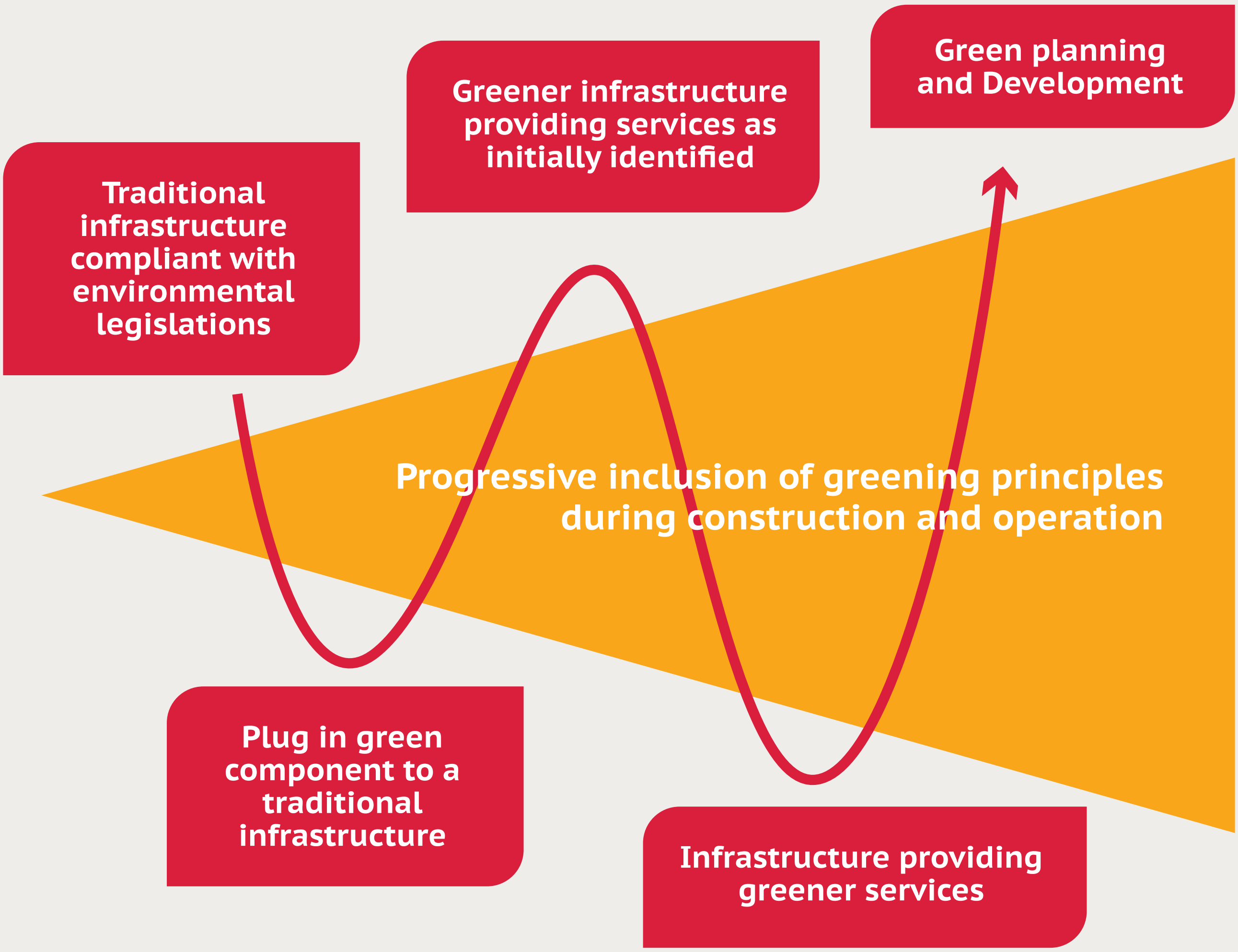
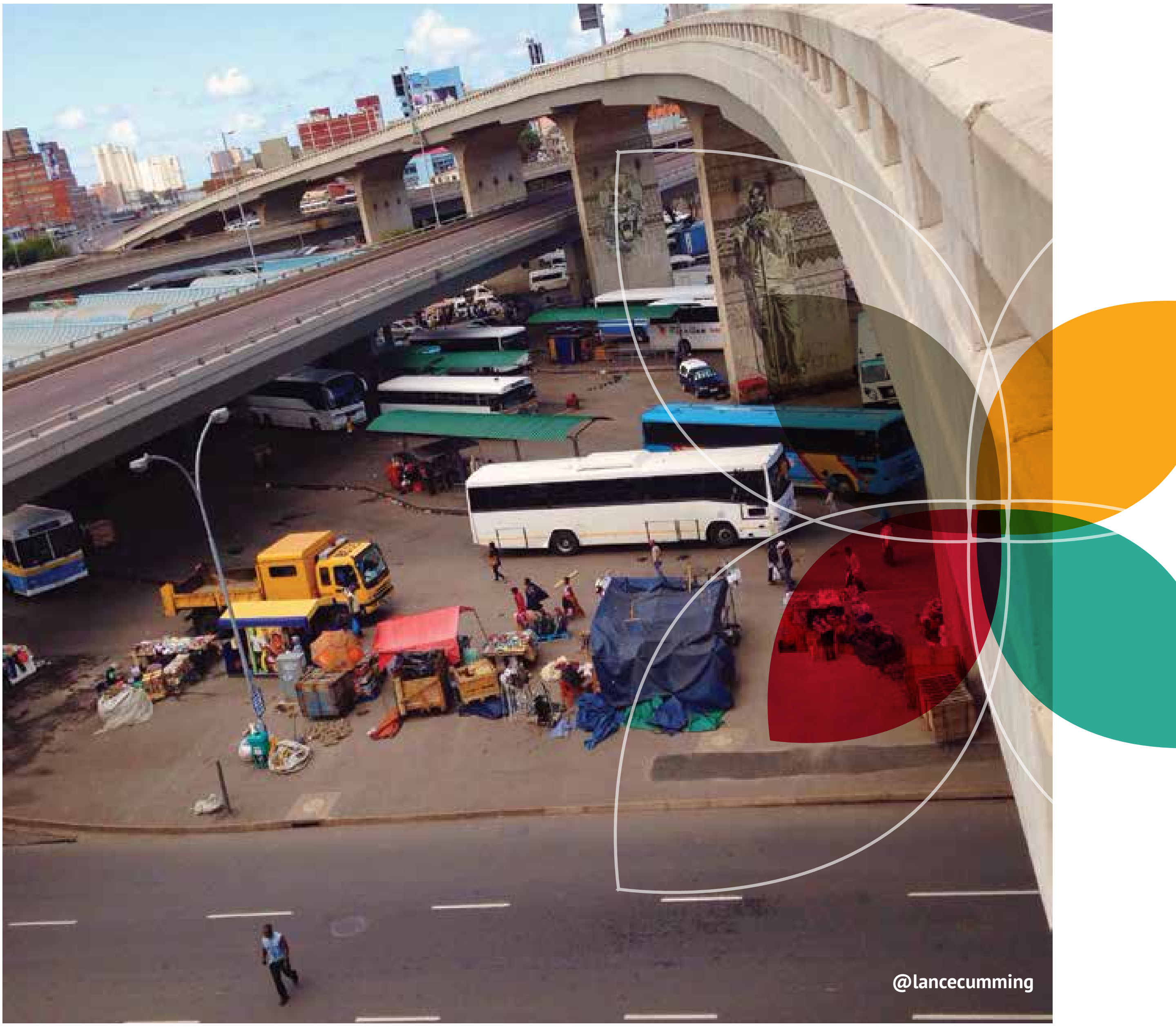


Figure 10: Towards green(er) infrastructure
Source: Giordano (2013:5)



From case studies referred to in this paper, it is evident that most urban ecological research has been conducted in cities of the global North. However, knowledge from developing countries, and their perspectives and governing paradigms, are gaining momentum and are much needed as important lessons can be learned from their practice of urban ecology and implementing green infrastructure in the midst of poverty and socio-economic problems. Green thinking is more than ad hoc tree planting or providing urban green spaces purely for aesthetic or recreational purposes. The added value of green infrastructure should be realised and captured in terms of social, environmental and economic benefits. Local authorities should explore and optimize the return on investment resulting from green infrastructure planning approaches, in an attempt to plan and develop sustainable cities, defined by SACN (2015b) as "a city that meets its developmental responsibility (social and economic needs) in a spatially transformed (equity) and resource efficient way (natural resources, economic & human capacity), thus going beyond the Brundtland definition of sustainable development, and including the ability to grow and prosper beyond reliance on resources consumption".

The Appendix shows some broad planning approaches and ways to incorporate green infrastructure. This is not a comprehensive plan for integrating green infrastructure planning but a point of departure for cities and local authorities to explore the possibilities of green thinking and creating green(er) cities.

APPENDIX: PLANNING APPROACHES TO STRENGTHEN AND INTEGRATE GREEN INFRASTRUCTURE

	Greening approach	Implementation examples
	Focus on integrative planning approaches	> Promote GI development on all spatial scales. > Encourage the integration of the natural and built environments. > Encourage intergovernmental cooperation. > Enhance multi-disciplinary collaboration and planning. > Ensure that key concepts are defined, understood and interpreted in the same context by all stakeholders. > Promote healthy ecosystems as the foundation for sustainable cities. > Include green building principles and principles of eco-cities. > Encourage interconnected systems within the urban landscape.
	Embed sustainability and resilience thinking into city planning	> Plan and develop spaces to provide multiple services. > Allocate responsibilities for managing land and monitoring the efficient consumption of resources. > Balance pro-developmental and pro-environmental planning approaches. > Encourage adaptive planning and experimental design approaches
	Provide necessary regulations to support green infrastructure planning	> Review existing regulations and how these regulations impact on green infrastructure planning initiatives. > Modify and change zoning regulations to allow green infrastructure planning initiatives such as urban agriculture. > Provide guidelines and training with regards to GI and the implementation thereof, through various forums and media. > Implement ordinances and laws that require integrated green infrastructure systems in every residential development. > Explore opportunities within SPLUMA. > Construct master plans and policies with green infrastructure planning and conservation as leading objectives. > Plan proactively even when there is no immediate threat of climate change or environmental shock. > Ensure that plans and policies incorporate the mandates of various departments and integrate goals and procedures with integrating core environmental objectives. Protect and maintain urban green space and expand green networks even when these spaces come under pressure for infill development.
	Enhance integration	> Planning for an effective urban green infrastructure typology should involve identifying a city’s current stage of green infrastructure development and mapping next steps to mainstream GI as an element of urban infrastructure.

Greening approach	Implementation examples
Protect and plan green networks	> Provide trees along sidewalks to maximize greening > Convert parking spaces into green land uses, such as outdoor seating spaces or urban gardens. > Clear vacant land parcels to make way for rain gardens and allotment gardens. > Demarcate outdoor retail areas with greening initiatives such as raised beds or pots instead of conventional railings. > Allow space for afforestation and increased green space cover. > Extend tree planting schemes beyond kerbside locations. > Encourage green roofs and green walls within cities.
Improve connectivity between green spaces	> Connectivity should be enhanced by an integrated blue-green network. > Improve connectivity by creating common green areas, linked by green corridors, ecological highways and greenways. > Establish a street connectivity ordinance that is customized to various local factors, such as topography, natural features, climate and desirable historical precedent. > Provide accessible pathways to amenities and consider pedestrian-only streets where appropriate. > Implement multi-way boulevards. > Allow space for canopy trees, street lighting, bus stops with seating/shelters, and pedestrian refuge. > Plan and manage a network of green spaces and geographically formed corridors aimed at conserving ES values and providing benefits to humans. > Encourage combined functions within the same space. > Encourage stacking of green functions and integration of functions.
Increase usable public green spaces	> Design shared spaces. > Implement multi-use spaces that can be used differently during certain times of the day, week, or year. > Generate green space typologies to include in mainstream planning. > Distribute green open spaces equitably. > Consider time-shifting approaches to enhance usage and effectiveness of the space.
Support green land uses that is compatible with adjoining land uses	> Encourage urban agriculture. > Identify areas that allow various activities such as planting, weeding and harvesting to be conducted safely and conveniently. > Encourage domestic food production on residential properties > Remove limitations to community gardening. > Support the development of nurseries for seeding production, forested nature areas, and conservation areas. > Support the rehabilitation of wetlands and bushlands. > Encourage tree planting schemes.
Encourage a comprehensive approach	> Relate spatial connectivity to the concept of ecological networks > Consider climate change interventions within the spatial reality. > Consider the environmental impact of mega projects and adequate planning and mitigation approaches thereof. > Identify and protect critical ecological hubs and linkages in advance of development. > Introduce a network of integrated parks and greenways that provide ecosystem services and link green spaces at regional level.

Greening approach	Implementation examples
Encourage innovative urban stormwater management	> Include trees bioswales and rain gardens to capture, filter, and infiltrate rain water. > Include filter strips beside paved areas to slow the flow of stormwater and reduce the volume of runoff. > Use rain barrels and cisterns to collect stormwater and use for irrigation. > Replace solid asphalt or concrete with pervious asphalt, pervious concrete, permeable pavers and plastic grid systems to allow water infiltration to tree root zones. > Build water storage vaults under impervious drive lanes and parking areas to capture rainwater and store it for reuse. > Consider combined sewer outflow systems. > Enhance natural draining systems to slow runoff and increase infiltration. > Make roads and sidewalks narrower and parking lots smaller to reduce total runoff. > Preserve open spaces in designs to provide areas where water can infiltrate or evaporate. > Retrofit drainage systems to accommodate retention ponds, green roofs and green spaces.
Integrate stormwater systems into the built environment	> Consider the design of green infrastructure and allow for inflow and outflow of the stormwater runoff. > Rehabilitate old quarries, parklands and mines into eco-tourism areas. > Encourage holistic planning approaches. > Encourage cooperation between different spheres and disciplines. > Develop both green and blue infrastructure networks with enhanced storage capacity to provide surplus water when disaster strikes and to absorb surplus water when needed.
Address community perceptions about the value of green spaces	> Encourage community participation in green infrastructure planning > Involve the community early on in the overall planning and design through various forums and media such as community meetings, design workshops, websites, blogs and social media. > Build partnerships with residents and businesses to enhance awareness about the importance and benefits of streetscape improvements. > Identify communities that have expressed interest in having agricultural areas and thus can be relied on to maintain these areas in a stewardship programme. > Use water art not only to collect runoff, but to change public perceptions about runoff. > Take note of advances in technological communication, such as social media, in reaching stakeholders; and gaining input from communities.
Encourage "green" education	> Educate the next generation about the challenges and benefits of GI. > Build partnerships with schools to teach students about green infrastructure and the benefits thereof. > Enhance environmental stewardship by involving civic organisations and individual volunteers. > Educate communities regarding the value and use of green infrastructure. > Encourage school greening projects.
Create green awareness through adequate design	> Provide amenities such as trees, shade structures, etc., as appropriate to the location to ensure optimum levels of comfort and convenience. > Design facilities that aesthetically enhance the community character. > Form partnerships between authorities and communities to involve community groups and other stakeholders in the selection, construction and maintenance of green infrastructure projects. > Introduce 'guerrilla gardening' initiatives as alternatives to conventional forms of stakeholder engagement. > Protect culturally significant green spaces and upgrade sites to improve green infrastructure uses. > Provide guidelines and training to the public for installing and maintaining green infrastructure through various forums and the media, including face-to-face workshops and the internet. > Encourage community food gardens. > Highlight the benefits of GI for communities.
Consider social issues as part of GI design	> Focus on pedestrian scale and character. > Provide wide sidewalks that allow pedestrian movement and include GI elements. > Integrate adjacent land uses with the sidewalk articulation. > Incorporate vertical elements, such as lighting, shade structures, trees and planting to bring human scale to the street. > Provide sufficient open space to accommodate child-friendly spaces and active play in various forms. > Use topography and grade changes such as steps, slopes and mounds, to create opportunities for socialization. > Consider the complexities within decision-making structures.

	Greening approach	Implementation examples
	Measure the value of GI	> Use toolkits to estimate the economic benefits of green spaces and GI. > Quantify environmental benefits through the use of toolkits, such as the Street Tree Resource Analysis Tool for Urban Forest Managers (i-Tree STRATUM) or ecoBudget. > Quantify GI value to stand against development pressures and built a business case for green spaces. > Consider ES and EDS as part of the measurements. > Create a list of measurable deliverables applicable to the local context. > Quantifiable values to be determined for both the household and neighbourhood levels.
	Create an imperative to act and promote GI	> Explore incentives when new developments incorporate green infrastructure approaches. > Use taxes and income generating activities to fund green infrastructure. > Promote the inclusion of green roofs in new developments and existing structures by waiving certain fees for developments that comply.
	Encourage economically sound design approaches	> Encourage low-impact landscaping. > Encourage use of recycled greywater from houses and buildings. > Plant climatically appropriate native and non-native plants with deep root growth and pest-resistance to improve the long-term viability of the site while minimizing maintenance costs. > Create designs that minimize maintenance requirements. > Use greywater from clothes washers, bathtubs, showers and bathroom sinks for irrigation. > Install greywater diversion valves to separate greywater from blackwater. > Use GI to reduce the amount of grey infrastructure needed for drainage and its related management costs.

***Sources for the table based on:** re:Streets (2016), Manufacturing Skills Australia (2011), Cleangreenfs (2014); Boyle et al. (2014); Tancott, (2013); Kramer (2014:1); Maco & McPherson (2003); Symons (2015:33); UN-Habitat et al. (2008: 21); Jansen and Ruifrok (2012: 18); Posthumus (2013); Laros (2012); Kithiia and Lyth (2011); EU (2013:17); DEA (2016); Carlet (2016); Afzalan & Muller (2014); Connolly et al. (2014); Haaland & van den Bosch (2015); Lennon, Salmond et al. (2014); Young et al. (2014)*

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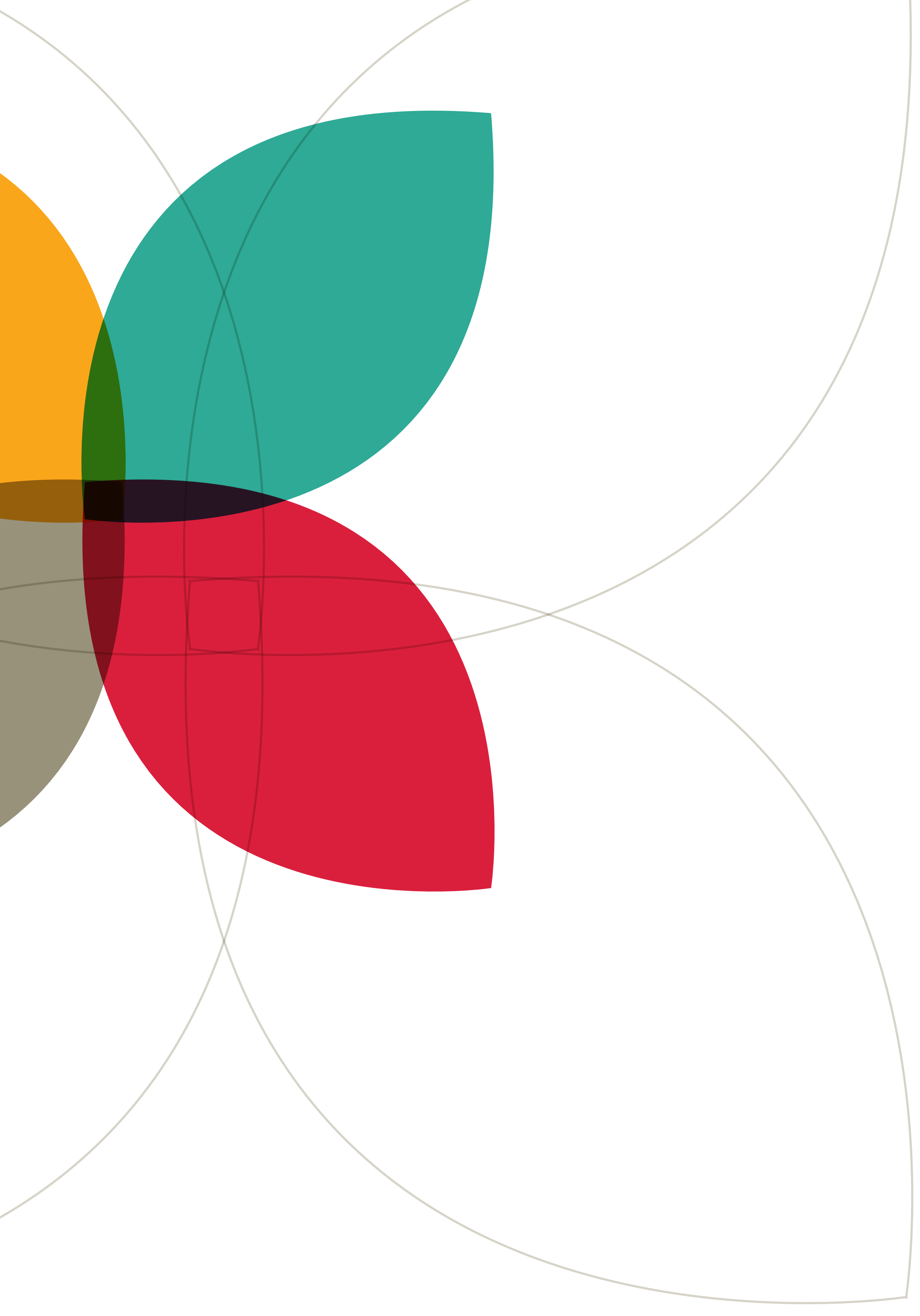

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