

The integration of Urban Planning and Urban Ecology: investigating multi-functionality and ecosystem services

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PREFACE

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ABSTRACT

This research departs from the understanding that ecological considerations should be an integral part of the thinking and decision-making processes of urban planners. These considerations emanate from the certainty that urban planners are responsible for the spatial arrangements of cities and that through land-use changes influence and often unknowingly undermine biodiversity, habitats, and ecosystem services (ESs). This research argues that environmental considerations could be enhanced if urban planners were adequately informed through a foundation of urban ecological aspects and if they understand the association between such ecological considerations and urban planning related practices. This research investigates the integration of urban planning and urban ecology with a special focus on the nexus between multi-functionality and ESs from an urban planning perspective.

A thematic literature investigation was conducted to explore ecological considerations from an urban planning point of view, including the themes of 1) urban planning and urban ecology, 2) green infrastructure (GI) elements 3) ESs and 4) multi-functionality. With a call for empirical evidence from a developing country perspective, the empirical investigation initiated with qualitatively exploring South African context case-studies, in attempt to assess the connection between the ecological considerations and the spatial reality. To further gain an understanding of South African urban planning practice complexities, the empirical investigation employed a quantitative investigation based on an electronically conducted survey amongst South African registered planners, to reflect on their knowledge of ecological considerations, and the current integration of such in urban planning practice.

Ultimately, the research discovered that the multi-functionality principle has the potential to guide urban planning practice by integrating both urban planning practices (GI planning) and ecological considerations (ESs). The research concluded that the multi-functionality principle is considered the connector between the ecological considerations and guides spatial planning towards an ecological approach. South African urban planners are however not yet including these ecological considerations into mainstream planning sufficiently. The empirical evidence argued that a lack of adequate knowledge of ecological considerations is the main reason behind the difficulty of integrating it in urban planning practice.

The research results contribute to the gathering valuable information and opportunities for further planning research on ESs and multi-functionality, that also enhances broader GI planning as part of mainstream urban planning approaches. The research calls for future planning research to utilise the benefits of ESs and multi-functionality as a foundation and inspiration to further

prioritising ecological approaches as part of mainstream urban planning practices of contextualised cities across the globe.

Key terms: *Urban planning; urban ecology; ecosystem services; multi-functionality; green infrastructure; South African urban planning practice.*

OPSOMMING

Hierdie navorsing spruit uit die begrip dat ekologiese oorwegings 'n belangrike deel moet vorm van die denk- en besluitnemingsprosesse van stedelike beplanners. Hierdie oorweging ontstaan uit die sekerheid dat stedelike beplanners verantwoordelik is vir die ruimtelike beplanning van stede en dat die besluitneming en verandering van grondgebruik die biodiversiteit, habitats en ekosisteedienste (ES's) van stede dikwels beïnvloed. Hierdie navorsing voer aan dat omgewingsoorwegings verbeter kan word as stedelike beplanners voldoende ingelig word oor stedelike ekologiese aspekte en die verband tussen sulke ekologiese oorwegings en stedelike beplanningsverwante praktyke. Hierdie navorsing ondersoek die integrasie van stedelike beplanning en stedelike ekologie met 'n spesifieke fokus op die verband tussen meerfunksionaliteit en ED's vanuit 'n stedelike beplanningsperspektief.

'n Tematiese literatuurondersoek was gedoen om ekologiese oorwegings vanuit 'n stedelike beplanningsoogpunt te ondersoek, insluitend die temas van 1) stedelike beplanning en stedelike ekologie, 2) groen infrastruktuur (GI)-elemente 3) ED's en 4) meerfunksionaliteit. Met 'n beroep op meer empiriese bewyse vanuit 'n ontwikkelende land se perspektief, is die empiriese ondersoek ingestel op 'n Suid-Afrikaanse konteks. Gevallestudies is kwalitatief ondersoek om die verband tussen die ekologiese oorwegings en die ruimtelike werklikheid te beoordeel. Om die Suid-Afrikaanse kompleksiteit in stedelike beplanning verder te begryp, het die empiriese ondersoek gebruik gemaak van 'n kwantitatiewe ondersoek gebaseer op 'n elektroniese opname wat onder Suid-Afrikaanse geregistreerde beplanners gedoen is. Daar is besin oor hul kennis van ekologiese oorwegings, en die huidige integrasie daarvan in stedelike beplanning.

Ten einde het die navorsing bevind dat die meerfunksionaliteit beginsel die potensiaal het om stedelike beplanningspraktyke te lei deur beide stedelike beplanningspraktyke (GI-beplanning) en ekologiese oorwegings (ED's) te integreer. Die navorsing het tot die gevolgtrekking gekom dat die meerfunksionaliteit beginsel die skakel is tussen die ekologiese oorwegings en dat dit ruimtelike beplanning na 'n ekologiese benadering rig. Suid-Afrikaanse stadsbeplanners maak hierdie ekologiese oorwegings nog nie voldoende deel van hoofstroombeplanning nie. Die empiriese bewyse het aangevoer dat 'n gebrek aan voldoende kennis van ekologiese oorwegings die hoofrede is agter die probleme van voldoende integrasie van daarvan in stedelike beplanning praktyk.

Die navorsingsresultate dra by tot die versameling van waardevolle inligting en geleentheid vir verdere beplanningsnavorsing oor ED's en meerfunksionaliteit, wat GI-beplanning verbeter as deel van die hoofstroombenaderings vir stedelike beplanning. Die navorsing moedig toekomstige

beplanningsnavorsing aan om die voordele van ED's en meerkunksionaliteit te benut as 'n grondslag en inspirasie om ekologiese benaderings verder te prioritiseer as deel van die hoofstroompraktyke vir stedelike beplanning van gekontekstualiseerde stede regoor die wêreld.

Sleuteltermes: *Stedelike beplanning; stedelike ekologie; ekosisteemdienste; meerkunksionaliteit; groen infrastruktuur; Suid-Afrikaanse stedelike beplannings praktyk.*

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CHAPTER 1 – INTRODUCTION

1.1 Point of departure

In recent years there has been an expanding scientific understanding regarding nature-based solutions as an opportunity for the multiple issues urban areas are confronted with (Escobedo *et al.*, 2019:3). During the recent global COVID-19 pandemic the value of preserving and further developing quality green spaces was once again highlighted (Kleinschroth & Kowarik, 2020:318). Accordingly, this public health emergency urged urban planners to rethink and reprioritise ecological considerations as part of urban planning practice for improved quality of life and human health and well-being (Ugolini *et al.*, 2020:1). Several researchers have recognised and emphasised that urban planning practice should become more holistic and should combine advanced urban ecological concepts, knowledge, and aspects within urban planning activities (Marcotullio & Boyle, 2003:6; Ahern *et al.*, 2014:245; Steiner, 2014:1; Tan & Jim, 2017:15; Osmond & Pelleri, 2017:31; Wamsler *et al.*, 2014:19; Geneletti *et al.*, 2020:1). Specifically, ecological aspects and concepts of urban ecology, green infrastructure (GI), urban ecosystems, and ecosystem services (ESs) are recommended by planning research to become a part of urban planners “necessary toolkit” to plan urban areas (Gómez-Baggethun & Barton, 2013: 235; Abass *et al.*, 2019:1; Cortinovis & Geneletti, 2019:1).

The Green Infrastructure (GI) approach arose internationally as an opportunity to improve and positively influence the quality of urban areas (Abass *et al.*, 2019:1; Cortinovis & Geneletti, 2019:1). Even though GI is an aesthetical component of the urban fabric, it is furthermore acknowledged as a functional “resource” for cities that provide multiple ESs (Ugolini *et al.*, 2020:1). The Millennium Ecosystem Assessment (MEA) stresses the need for ESs in urban areas to enhance quality of life, healthy environments, and human well-being (MEA, 2005:49). Lindley *et al.* (2018:338) claim ESs should perhaps form the foundation of urban planning decision-making in African cities, struggling with challenges of high levels of urbanisation, poverty, lack of access to basic services, poor infrastructure (Cilliers, 2019a:455), loss of biodiversity and pressure on green spaces within and around urban areas (Ahmed & Puppim de Oliveira, 2017:1741). In developing countries, such as South Africa, Bobbins and Culwick (2015:33) acknowledge that ecological aspects remain ambiguous and are not yet fully integrated as part of mainstream urban planning practice. Abass *et al.* (2019:2) claim that cities in developing countries do not yet recognise and appreciate the benefits and quality of ecological aspects.

Ahern *et al.* (2014:254) and Lindley *et al.* (2018) call for innovative approaches towards urban land-use practices. Urban planning practices should especially make a stronger connection to

ESs (Kremer *et al.*, 2016:29). Accordingly, Ahern *et al.* (2014:254) urge planners to incorporate emerging new ecological knowledge, including advanced knowledge of the urban ecology discipline within urban planning practice. Moreover, to bridge the practice-gap between urban planning and ecological aspects, it is further recommended to enhance planning for GI (Lo & Jim, 2010:460; Kremer *et al.*, 2016:29), with specific emphasis on achieving the multi-functionality principle of GI (Anderson *et al.*, 2016:448; Hansen *et al.*, 2019:99). Hansen *et al.* (2019:100) describe the principle of multi-functionality in terms of GI as the capacity of GI elements (green spaces) to provide maximum ESs within limited available urban spaces (Belmeziti *et al.*, 2018:2). This research departs from the understanding that the ecological concept of ESs should be recognised alongside GI planning as an essential part of planners thinking and decision-making processes. GI planning holds the ability to directly incorporate ecological knowledge within urban planning activities (Mell, 2013:29) and urban planning practice should consider multi-functionality, as one of the core principles of GI planning, as a strategy to incorporate ESs into mainstream urban planning practice. This research argues that such ecological approaches as part of mainstream urban planning should be captured and placed in a local context as a foundation and inspiration for deliberation and action in African cities (Lindley *et al.*, 2018:338).

1.2 Problem statement and research motivation

To summarise, literature reveals multiple shortcomings in the practice of planning for ecological aspects and concepts such as ecosystem services and multi-functionality:

- Urban ecological concepts, especially concepts of GI and ESs, and the incorporation of ecological knowledge are often misunderstood or still unknown to many urban planners (Cilliers & Cilliers, 2016:39; Di Marino *et al.*, 2019:664; La Rosa, 2019:1) preventing urban planners from incorporating ecological considerations into mainstream urban planning (Di Marino *et al.*, 2019:664).
- GI studies have predominantly leaned towards developed countries (Du Toit *et al.*, 2018). A lack of evidence exists to support planning for GI in developing country decision-making (Culwick, 2019), for example in South Africa (Cilliers, 2019a:455).
- As a resource to support GI, GI typologies are required and can be helpful to communicate the range of GI to urban planners and other decision-makers that is possible for implementation (Hansen *et al.*, 2017:31). GI is classified by various authors into a range of typologies to be included in mainstream urban planning (Young *et al.*, 2014: 2572). These typologies vary across countries. Cilliers and Cilliers (2016:10) however, acknowledged that South African GI typologies are considerably more limited than international examples.

- Abass *et al.* (2019:2), Heymans (2019) and Lindley *et al.* (2018:338) claim African cities do not yet recognise and appreciate the quality of green spaces and that the ESs provided by these spaces are often taken for granted. This problem arises seeing the fact that empirical evidence on the integration of GI in urban planning has a limited focus on the benefits or ESs (Pozoukidou, 2020:1) and planners are thus unfamiliar with the GI elements to generate the necessary ESs (Belmeziti *et al.*, 2018:2). Lindley *et al.* (2018:338) therefore calls for urban planners in developing countries to be familiarised with and to appreciate ESs and multi-functionality as core aspects of GI.
- The ESs concept, however, remains mainly unfamiliar to a large majority of urban planners regarding terminologies, examples, and the benefits thereof (Di Marino *et al.*, 2019:644; La Rosa, 2019:1). From a developing country perspective, there remains a need for evidence to inform urban planners on the ESs concept or to provide them with a guide around the multiple ESs generated from GI elements (O'Farrell *et al.*, 2012:29; Lindley *et al.*, 2018:338). From this perspective, urban planners and decision-makers could further be informed on the benefits of GI and their value for rapidly growing African cities (Lindley *et al.*, 2018:338).
- According to Hansen *et al.* (2019:99) and Breuste *et al.* (2020:440) knowledge regarding multi-functionality in urban planning practice remains elusive and poorly conceived by many urban planners worldwide (Niemelä *et al.*, 2010:3229; Anderson *et al.*, 2016:446). Especially in the South African context, Cilliers (2019a:445) acknowledges multi-functionality as being undervalued by urban planners.
- The literature on multi-functionality furthermore emphasises that more research regarding the multi-functionality of GI elements (Iojă *et al.*, 2014:705; Wei, 2017:26; Belmeziti *et al.*, 2018:2). Bolund and Hunhammar (1999:297), as well as Anderson *et al.* (2016:446) claim to focus on the GI elements, as these spaces generate easily accessible ESs used by a greater variety of urban dwellers to improve their quality of life.
- It is questionable whether planners adopt ecological aspects and concepts (such as GI, ESs, and multi-functionality) in planning practice or if these ecological concepts are only considered on a theoretical level (Hansen & Pauleit, 2014:517). According to Schäffler and Swilling (2013:247) there is a shortage of empirical evidence on whether and how ecological aspects and concepts such as ESs and multi-functionality are considered by local urban planners. Whether environmental worldviews are related to the state of inclusion of GI, ESs, and multi-functionality in planning practice is also unaddressed in South African urban planning research, which supports the call for empirical evidence on current South African urban planning practice considerations.

In light of the problems identified above, a pressing need was identified regarding informing urban planners with a foundation of urban ecological aspects and concepts possible for consideration in the urban planning practice, as well as associating such ecological considerations with urban planning related practices. As motivation, this research explores both the concepts of ESs, and multi-functionality as a GI planning principle. Accordingly, the research aim, and objective are provided as follows.

1.3 Aims and objectives

The main aim of this study can be captured as: to investigate the nexus between ecosystem services (ESs) and multi-functionality as point of departure to strengthen ecological approaches as part of mainstream urban planning.

In support of the main aim identified above, the research objectives include:

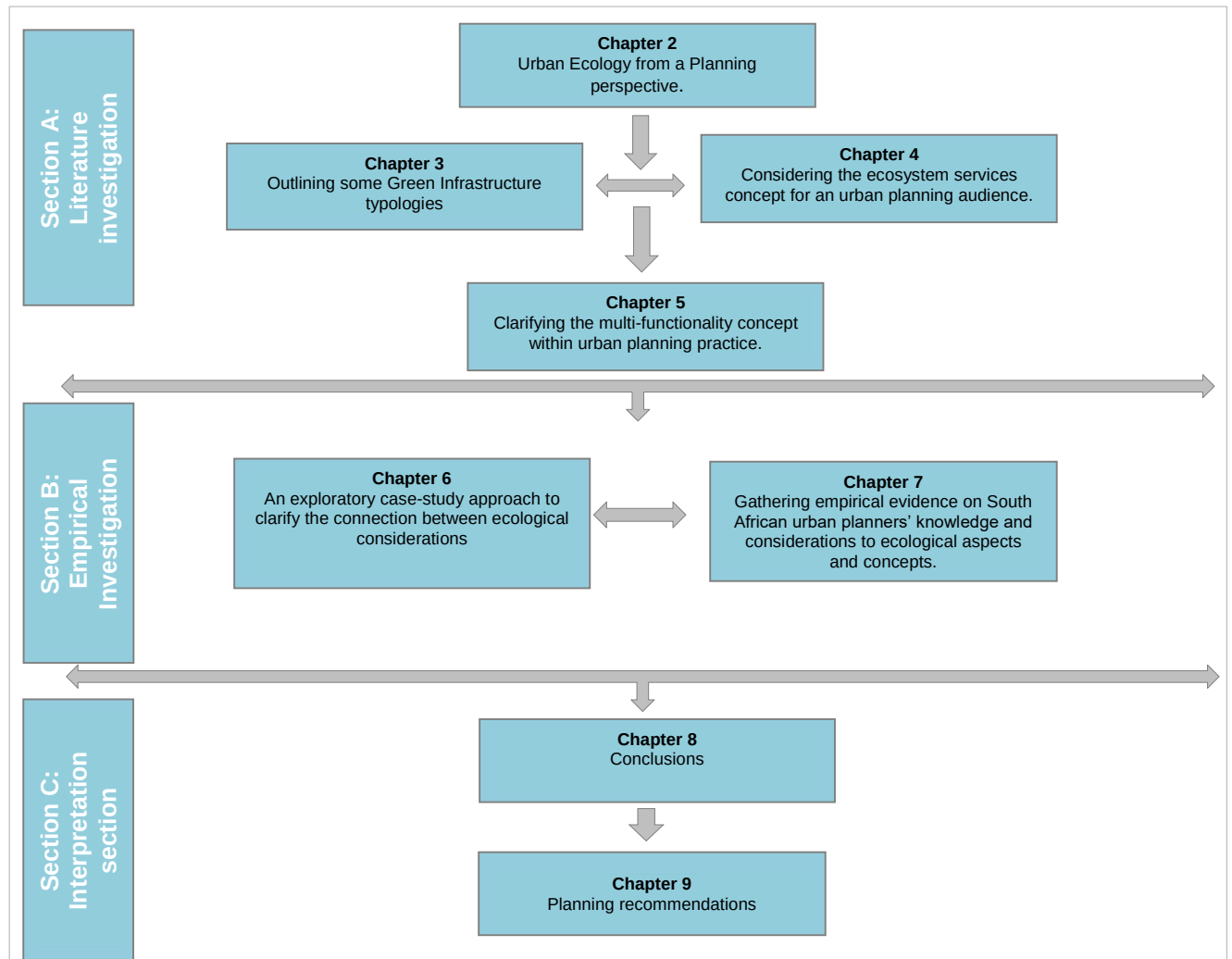
- i. To reflect on the interface between urban planning and urban ecology.
- ii. To outline typologies of GI according to various international and local studies (South African) in order to compose a comprehensive typology of GI elements for South African urban planning practice.
- iii. To consider the terminologies and interpretations of the ESs concept and to conceptualise ESs in an urban planning context.
- iv. To reflect on the multi-functionality concept in an urban planning context, as well as urban planning approaches to plan for multi-functionality.
- v. To assess best practice examples, within a South African context, regarding ESs generated by the identified inventory of GI elements.
- vi. To determine which GI elements, advance multi-functionality.
- vii. To capture the general knowledge and considerations among urban planners regarding the ecological aspects and concepts (ESs, GI planning and multi-functionality) in South African urban planning practice.
- viii. To determine the environmental worldview among South African urban planners and relation to considering ecological aspects and concepts in South African urban planning practice.

1.4 Methods of investigation

The concept “research methodology” refers to the framework for the chosen research methods and the manner of employing these methods. “Research methods” on the other hand are defined by Maccallum *et al.* (2019:8) as the *procedures* of collecting data from the real world for acquiring new knowledge. Upon studying **Figure 1-1**, the method of investigation for this research

dissertation was conducted in three main sections, including **Section A** - the literature investigation; **Section B** - the empirical investigation; and **Section C** - the interpretation section (conclusions and recommendations).

Figure 1-1: Structure of the dissertation.



Source: Own construction (2020).

The methodology and methods employed in each section of **Figure 1-1** is explained in the following sub-sections.

1.4.1 Section A: Literature investigation

For the purpose of this dissertation, the literature investigation was written based on theoretical and conceptual underpinnings of previous research related to the research aim. The study followed a thematic review structure by capturing literature according to relevant themes. The themes included 1) urban planning and urban ecology, 2) green infrastructure elements; 3) ecosystem services; and 4) multi-functionality. Each theme draws on existing knowledge, key aspects or terms associated with the above-mentioned themes. The literature investigation included both international and South African academic articles, books, book chapters, theses,

reports, surveys, and grey literature as sources. These sources were obtained from various databases that are accessible via the North-West University's Ferdinand Postma Library databases, in particular, Google Scholar, ScienceDirect, Scopus, and other accessible databases (refer to the bibliography of this study for a complete list of the literary sources exploited). The specific search criteria followed to exploited sources depended on the relevant research theme and related research objectives. **Table 1-1** captures each research theme and the related research terms and keyword combinations that were entered as search queries.

Table 1-1: Researched terms and keywords combinations searched for the purpose of the literature investigation.

Research sub-theme	Preliminary research terms searched	Keywords combinations (Boolean operators)
Urban planning and urban ecology (CHAPTER 2)	"Urban"; "urban ecology"; "ecology"; "ecosystems"; "ecological knowledge"; "ecology in cities"; "ecology of cities"; "ecology for cities"; "nature-based solutions"; "green infrastructure"; "green infrastructure planning"; "urban planning"; "ecological approach"; 'open spaces'; 'urban green spaces';	Urban AND ecology Ecology OR urban ecology Ecology AND ecosystems Urban planning AND urban ecology Urban ecology AND nature-based solutions' Ecology for cities AND urban planning Nature-based solutions AND urban planning Ecological knowledge AND urban planning Urban planning AND green infrastructure Open space OR urban green spaces Open spaces AND urban green spaces Urban green spaces NOT open spaces Green infrastructure AND green spaces
Green infrastructure elements (CHAPTER 3)	"Green infrastructure"; "typology"; "green spaces typology"; "International"; "South Africa"; South African urban planning"; "urban planning practice"; "Green infrastructure elements"; "green spaces"; "open spaces".	Green infrastructure AND green spaces AND open space AND typologies Urban planning AND green infrastructure AND typology Green infrastructure AND South Africa AND urban planning practice Green spaces AND South African urban planning South Africa AND green space typologies OR urban planning South Africa AND green infrastructure elements South African AND green infrastructure AND typology
Ecosystem services (CHAPTER 4)	"Ecosystems"; "green infrastructure"; "ecosystem services"; "ecosystem functions"; "urban ecosystem services"; "provisional services"; "regulating services"; "cultural services"; "supporting services"; "urban planning"; "urban planning practice"; "Environmental worldview"; "South Africa".	Ecosystems AND green infrastructure Ecosystem services AND ecosystem functions Urban ecosystem OR green infrastructure Urban ecosystems AND ecosystem services Green infrastructure AND provisional, regulation, cultural, and supporting services. Ecosystem services AND urban planning practice Urban planning practice AND environmental worldview South Africa AND urban planning practice OR ecosystem services South Africa AND environmental worldview
Multi-functionality (CHAPTER 5)	"Multi-functionality"; "urban planning"; "Planning for multi-functionality"; "Mixed land-use"; "urban landscape"; "green	Multi-functionality AND urban planning Mixed land-use AND multi-functionality Urban landscape AND multi-functionality Green infrastructure AND multi-functionality

Research sub-theme	Preliminary research terms searched	Keywords combinations (Boolean operators)
	infrastructure"; "ecosystem services"; "green infrastructure planning"	Ecosystem services AND multi-functionality Green infrastructure planning AND multi-functionality Sustainability AND multi-functionality

Source: Own construction (2020).

In addition to the sources gathered through the research terms in **Table 1-1**, other sources were also gathered through the snowball method. A snowball method to literature investigations entails the identification of new sources based on examining the bibliographies of previously gathered sources (Wohlin, 2014:3). For the purpose of this literature investigation the bibliographies of sources gathered through searches employed through the preliminary terms (**Table 1-1**) were snowballed to gather new sources. Sources were gathered to include the most recent sources. The sources gathered dated from 1983 to 2020. Older sources were included on merit, considering their relevance to the research theme.

After obtaining relevant sources, the sources were read and reviewed. Main concepts, ideas, relationships, and arguments were synthesised and grouped according to each research theme and research terms (**Table 1-1**). As a result, the literature investigation consists of four chapters (explained in section 2.1) providing contributions and building an advancing foundation of already gathered knowledge related to the research theme (Snyder, 2020:333). The literature investigation served as the foundation for the empirical investigation. Data gathered by means of the literature investigation were utilised in the empirical investigation to compile and prioritise a criterion for the exploratory case-study approach and guided the researcher in compiling questions for the survey-based research (discussed in detail in the following section).

1.4.2 Section B: Empirical investigation

For the empirical investigation a mixed-method research approach was employed. According to De Vos *et al.* (2011:66) a mixed-method research approach inquiry incorporates elements of both qualitative and quantitative approaches, allowing a more comprehensive understanding of a research problem or phenomenon. It is recognised that the urban planning discipline often employs more than one method to gather the information required (Maccallum *et al.*, 2019:10). The chosen research design for the mixed-method approach is an *embedded research* design. An embedded research design involves a larger design (either qualitative or quantitative) along with the idea to support the design by nesting qualitative or quantitative data within the large design (Creswell, 2014:44). The embedded research design for the dissertation included the following two research design components:

PART A: a qualitative exploratory case-study approach. The exploratory case-study approach qualitatively explored the connection between the ecological aspects and concepts (ESs, GI planning and multi-functionality). The approach initiated with exploring the ESs generated by South African best practice example GI elements. The dissertation employs the exploration of *best practice examples* to “act as an inspiration for innovation” (Bulkeley, 2006:1037) towards the enhancement of GI element implementation in urban planning practice. From this initial exploration, the qualitative findings were then utilised to determine the multi-functionality of the GI elements. The results are further utilised to conclude on the connection between the ecological aspects and concepts of GI planning, ESs and multi-functionality.

The second component of the empirical investigation (Part B) aimed to further investigate the phenomena, the ecological aspects, and concepts (ES, GI planning and multi-functionality), by means of survey-based research.

PART B: The embedded research design often includes to investigate a phenomenon within applied settings (Creswell, 2014:44). As such, quantitative data was gathered through survey-based research. The survey-based research was employed to reach a better understanding of South African urban planning practice regarding 1) the knowledge of ecological aspects and concepts among South African planners, 2) the current state of integration and implementation of such aspects and concepts in South African urban planning practice. The survey-based research furthermore aimed to determine the environmental worldview among respondents as South African urban planners and the relation to considering ecological aspects and concepts in South African urban planning practice. The data gathered and analysed was utilised to inform the practical implementation of the explored qualitative data (Part A) and thus played a supporting role in the larger embedded research.

More details on the research methods (data gathering and analysis) employed in the two empirical investigation components are provided respectively in Chapter 6 (Part A - qualitative component) and Chapter 7 (Part B - quantitative component) of the dissertation.

1.4.3 Section C: Interpretation section

Conclusions were drawn based on the links between the literature investigation and the data gathered in the empirical investigation. Thereafter planning recommendations were made based on the outcome of conclusions drawn. The conclusions were drawn, and recommendations were made to contribute to the urban planning profession and to guide South African urban planning practice towards a strengthened ecological approach in mainstream urban planning.

1.5 Structure of research dissertation

Table 1-2 illustrates the three research sections of the dissertation, along with the respective chapters of each section.

Table 1-2: The structure of research dissertation.

Section A: Literature investigation	Chapter 2: Urban ecology from a planning perspective.	The chapter provides an overview of the concepts and perspectives of the urban ecology discipline. Further discusses in the chapter is the interface between urban planning and urban ecology. The chapter concludes with GI and the GI planning approach as the interface between urban planning and urban ecology.
	Chapter 3: Outlining Green Infrastructure typologies	The chapter aims to capture different typologies of green spaces functioning as GI elements, derived from both international and South African literature, and concluded with a comprehensive typology inventory of GI elements based on the findings of the chapter which will be utilised as criteria to be assessed in Section B (empirical investigation).
	Chapter 4: The ecosystem services concept for an urban planning audience.	This chapter captured the terminologies, significance, and benefits of ESs and describes and conveys them to an urban planning audience who may not be familiar with the concept and the potential thereof. The chapter further reflects on ESs in urban planning practice, as well as on environmental worldviews and other aspects influencing the integration of the ESs concept in urban planning practice. Ultimately, the criteria of ESs that is compiled in this chapter are utilised in the empirical investigation (section B).
	Chapter 5: Clarifying the multi-functionality concept within urban planning practice.	This chapter includes a review of the multi-functionality concept in the urban planning context. The aim of the chapter is for urban planners to comprehend the different approaches to achieve multi-functionality through urban planning practice, primarily to achieve multi-functionality through the GI planning approach to contribute to a variety of ESs.
Section B: Empirical investigation	Chapter 6: An exploratory case-study approach to clarify the connection between ecological considerations.	Chapter 6 includes Part A of the empirical investigation, namely a qualitative research method to the exploratory case-study approach. The chapter qualitatively explores the ESs generated by South African best practice examples GI elements. The findings are then utilised to determine the multi-functionality of the GI elements, as well as the connection between the ecological considerations within the urban planning context.
	Chapter 7: Gathering empirical evidence on South African urban planners' knowledge and considerations to ecological aspects and concepts.	Chapter 7 includes Part B of the empirical investigation, namely the quantitative research method to the survey-based approach. Data are gathered by means of electronic surveys to purposefully selected South African urban planning practitioners. Frequencies and cross-tabulations of the questionnaire results will take place to reflect on the state of current integration and implementation of ecological aspects and related concepts in South African planning practice. Furthermore, the chapter reflects on the environmental worldview of the sample of urban planners and the relation to considering ecological concepts in South African urban planning practice.
Section C: Interpretation section	Chapter 8: Conclusions.	In line with the research objectives identified in section 1.3 the findings of both the literature- and empirical investigation will be discussed. Conclusions will be drawn as the basis for the planning recommendations to follow.
	Chapter 9: Planning recommendations.	This chapter makes planning recommendations based on the conclusions reached in Chapter 8 and in line with the objectives identified for this study. Along with specific considerations and recommendations for urban planning practice, this chapter also presented opportunities for future planning research to build on the findings of this research dissertation.

Source: Own construction (2020).

1.6 Limitation of the research

The qualitative exploratory case-study approach (c.f. 1.4) was limited to a lack of well-documented South African case-studies (as explained in detail in section 6.3.1). The chosen best practice examples of GI elements (case-studies) for the qualitative exploratory case-study approach are case-dependent on and therefore, the ability to generalise the findings may be narrowed. In agreement with qualitative research, the intention of this empirical investigation was not to generalise the findings (Cooper & Schindler, 2008:168) but as point of departure to emphasis to urban planning planners the connection and opportunity to plan for ESs through planning for different GI elements and the GI principle of multi-functionality.

1.7 Definitions

Table 1-3 includes definitions of applicable terminologies utilised within the dissertation.

Table 1-3: Glossary.

TERM	DEFINITION
Cultural services	Non-material benefits obtained upon visits to an ecosystem and benefiting the cultural or spiritual needs of humans (Gómez-Baggethun <i>et al.</i> , 2013:178).
Ecology	A science studying the interaction, distribution, abundance, functions and behaviour between organisms and their living environment (biotic) and non-living environment (abiotic) (Mcintyre <i>et al.</i> , 2008:7; Miller & Spoolman, 2011:52; Barot <i>et al.</i> , 2019:475).
Ecological consideration	Tending to benefit, protect or cause minimal damage to the environment, including environmental compliances, conservation and protection of fauna and flora, rational use of natural resources, and to pay attention to those functional areas that has an impact on the environment during the planning process. Within this dissertation ecological considerations includes and refers to "ecological aspects and concepts".
Ecological aspects and concepts	General understandings of concepts and themes relevant to integrating an ecological approach in urban planning, including the aspects and concepts of ecology, urban ecology, resilience, ecosystem services, biodiversity, landscape, and green infrastructure (Heymans <i>et al.</i> , 2019:4-8).
Ecosystem disservices	Ecosystem services that cause environmental costs or social nuisances. These ecosystem services are negative and harmful to human well-being or unwanted by citizens seeing that the services have financial costs (Escobedo <i>et al.</i> , 2011:2079).
Ecosystem functions	The biotic and abiotic processes within and between ecosystems delivering functions such as air filtering, temperature regulation, and water storage, filtration, and water drainage (Williams <i>et al.</i> , 2009:569).
Ecosystem services	The benefits all living species (especially humans) derive directly or indirectly from the capacity (function) of ecosystems to provide goods and services that satisfy needs (Secretariat of the Convention on Biological Diversity, 2012).
Environmental worldview	The "lens or filter" through which an individual sees or believes in the relationship humanity has with the natural environment as well as their assumptions about the natural environment itself (Colby & Mundial, 1989:5; Kollmuss & Agyeman, 2002:239; Schultz <i>et al.</i> , 2005:457). Also recognised as an "environmental paradigm".
Green infrastructure	An interconnected network within an urban area, consisting of a broad range of environmental features (including all natural, semi-natural and artificial green spaces and blue spaces) planned, design and managed to conserve ecosystem functions, contributing to biodiversity, conservation and providing benefits (social,

TERM	DEFINITION
	economic, and health benefits) to humans and the natural environment by delivering multiple ecosystem services (Benedict & McMahon, 2002; Benedict & McMahon, 2006; Cilliers & Cilliers, 2016).
Green infrastructure elements	All natural, semi-natural and artificial green spaces and blue spaces ranging in size and scale are GI elements of the broader GI of urban areas (Mell, 2010:15).
Green infrastructure planning	A strategic planning approach that aims to develop networks of green and blue spaces in urban areas, designed and managed to deliver a wide range of ecosystem services and other benefits at all spatial scales (Hansen <i>et al.</i> , 2017:1).
Multi-functionality as a land-use concept	The possibility of having more than one land-use and activity or function within the same urban space (Batty <i>et al.</i> , 2004:325).
Landscape multi-functionality	The combination of several functions, including different socio-economic benefits provided by a variety of land-uses within a single urban landscape (Ghafouri, 2016:36) or considering multiple natural and built (infrastructure) space as a whole (Živković <i>et al.</i> , 2019:206).
Multi-functionality as a GI principle	The capacity of GI elements to provide multiple ecosystem services (Hansen <i>et al.</i> , 2019:100).
Nature-based solutions	Solutions that are inspired by or copied from nature to provide human well-being and biodiversity benefits to urban areas (van den Bosch & Sang, 2017: 373; IUNC, 2020).
Provisioning services	The services that describe the physical products, materials, and goods derived from ecosystems and are directly consumed by humans (De Groot <i>et al.</i> , 2002:395; Grunewald <i>et al.</i> , 2015:13).
Regulating services	The indirect services obtained from the environmental functions or process carried out by the ecosystems (Anderson <i>et al.</i> , 2016:446).
Urban	A spatial heterogeneous area, predominantly comprised of a mosaic landscape of anthropogenic surfaces (e.g., building surfaces and physical structures), and natural elements (e.g., natural habitats, natural resources, natural processes), along with the concentration of human activities regulated by different land-uses (e.g., residential, industrial, commercial, and recreational) with a noticeable high population density. Considered an oversight concept for cities, and suburbs, towns, townships, and informal settlements (Pickett & Cadenasso, 2006:115; Feng & Tan, 2017:43; Osmond & Pelleri, 2017:33).
Urban ecology	An interdisciplinary field that aims to understand how human and ecological processes could coexist in human-dominated environments, to guide societies with their efforts to become more sustainable (Marzluff <i>et al.</i> , 2008).

Source: Own construction based on Colby and Mundial (1989); Benedict and McMahon (2002); De Groot *et al.* (2002); Kollmuss and Agyeman (2002); Batty *et al.* (2004); Schultz *et al.* (2005); Benedict and McMahon (2006); Pickett and Cadenasso (2006); Marzluff *et al.* (2008); McIntyre *et al.* (2008); Williams *et al.* (2009); Mell (2010); Escobedo *et al.* (2011); Miller and Spoolman (2011); Secretariat of the Convention on Biological Diversity (2012); Gómez-Baggethun *et al.* (2013); Grunewald *et al.* (2015); Anderson *et al.* (2016); Cilliers and Cilliers (2016); Feng and Tan (2017); Hansen *et al.* (2017); Osmond and Pelleri (2017); van den Bosch and Sang (2017); Barot *et al.* (2019); Hansen *et al.* (2019); Heymans *et al.* (2019); Živković *et al.* (2019); IUNC (2020).

1.8 Abbreviations and acronyms

The following abbreviations and acronyms included in **Table 1-4** are used in the dissertation.

Table 1-4: Abbreviations and acronyms.

CSIR	Council for Scientific and Industrial Research
DMOSS	Durban Municipal Open Space System
DSP	Dominant Social Paradigm

EDSs	Ecosystem disservices
EI	Ecological Infrastructure
ESs	Ecosystem Services
GI	Green Infrastructure
IGS	Informal Green Spaces
NEP	New Environmental Paradigm
MEA	Millennium Ecosystem Assessment
NBS	Nature-based solutions
SA	South Africa
SACPLAN	South African Planning Council for Planners
SANBI	South African National Biodiversity Institute
TEED	The Economic of Ecosystem and Biodiversity
UN	United Nations

SECTION A – LITERATURE INVESTIGATION

The aim of the literature investigation is to “map and assess” what has been written on specific research themes, as well as to identify research gaps and opportunities (Snyder, 2019:333; Maree, 2020:28). The literature investigation themes were identified in Chapter 1 as 1) urban planning and urban ecology, 2) green infrastructure elements; 3) ecosystem services; and 4) multi-functionality. As seen in **Figure A**, each of these themes are related to a literature investigation chapter and each chapter builds on the discussion of a previous chapter.

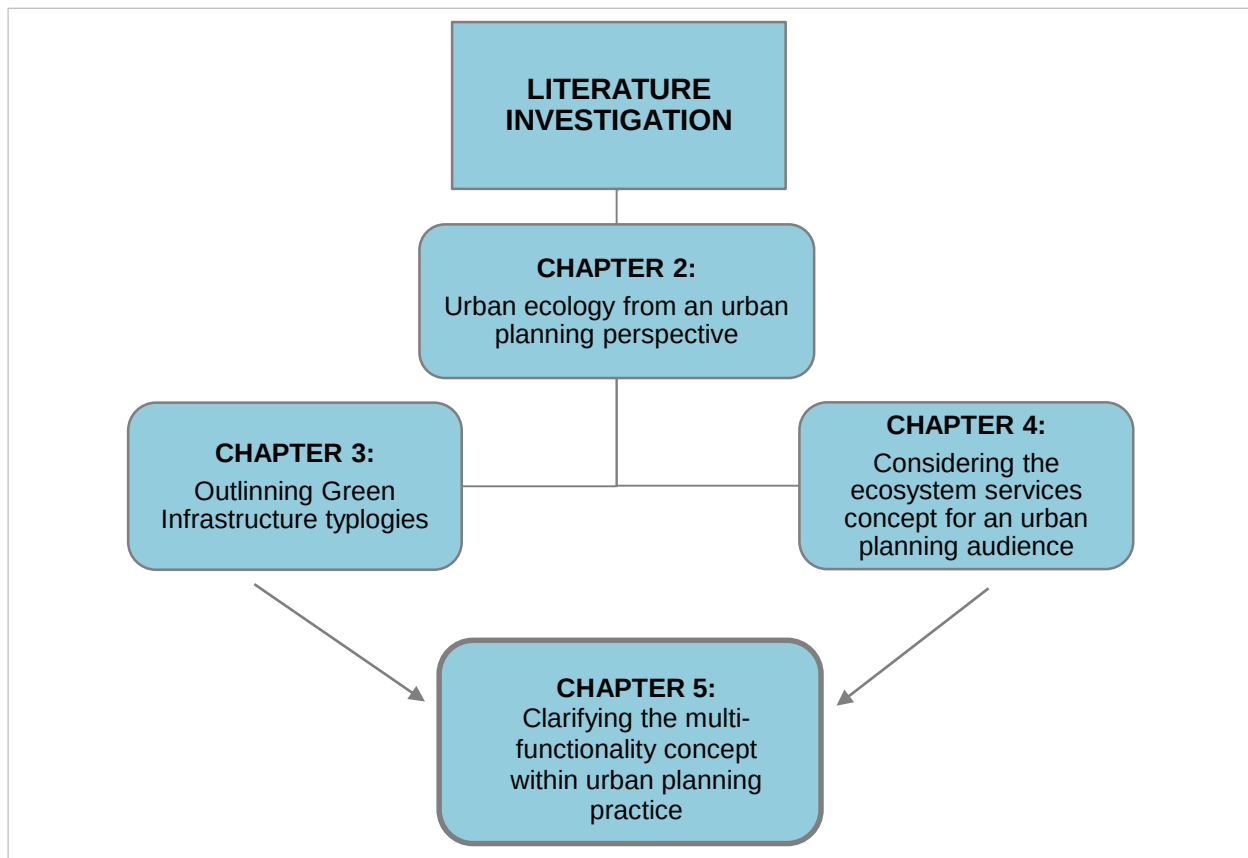


Figure A: The structure for the literature investigation of the dissertation.

Source: Own construction.

CHAPTER 2 – URBAN ECOLOGY FROM A PLANNING PERSPECTIVE

2.1 The structure of the chapter

Figure 2-1 illustrates the structure for Chapter 2.

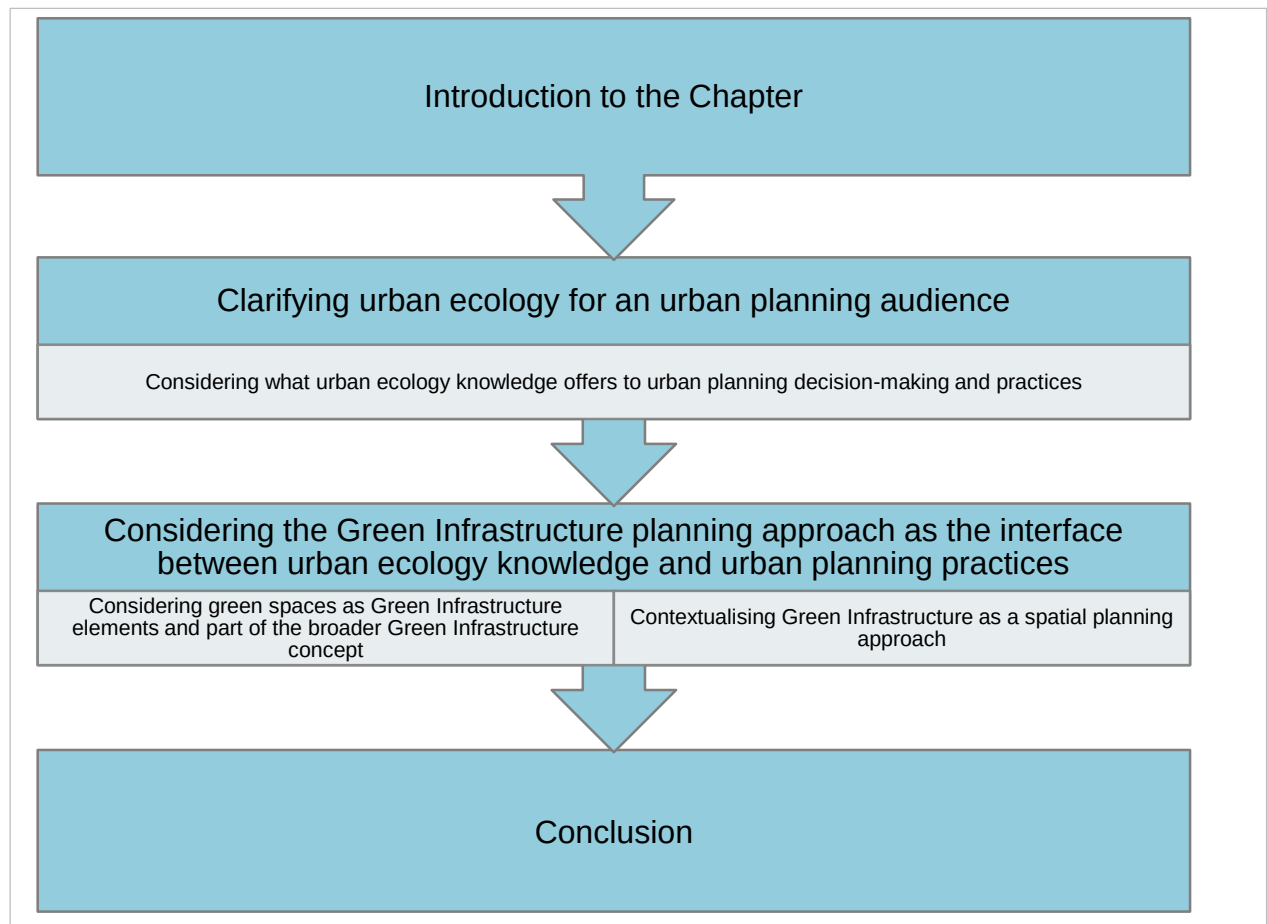


Figure 2-1: The structure of Chapter 2.

Source: Own construction (2020).

2.2 Introduction to the Chapter

In Chapter 1 it was mentioned that urban planning practice ought to follow a holistic approach by integrating advanced urban ecological knowledge and approaches into urban planning practice and processes (Niemelä, 1999:119; Marcotullio & Boyle, 2003:6; Ahern *et al.*, 2014:245; Steiner, 2014:1; Tan & Jim, 2017:15; Osmond & Pelleri, 2017:31; Wamsler *et al.*, 2014:19; Geneletti *et al.*, 2020:1). Several authors claim that urban ecology promotes opportunities to employ nature-based knowledge in cities as a future path (way of thinking) to guide urban planning towards sustainable and healthier urban environments (Douglas, 2010: xx; Luederitz *et al.*, 2015:98; Steiner, 2016:108; Geneletti *et al.*, 2020:67). This, however, requires that urban planning practice to incorporate ecological knowledge and innovative approaches that are not necessarily yet a

priority in mainstream urban planning practice (Ahern *et al.*, 2014:255). For urban planners to integrate ecological knowledge into urban planning practice require planners to comprehend urban ecological knowledge (Wu, 2008:46; Steiner, 2016:108) and to be “be up-to-date” with the urban ecological discipline (Steiner, 2016:108). McDonnell *et al.* (2009:10) therefore urge more research on the interface between urban planning and urban ecology, this includes application strategies on how to convert urban ecological knowledge into urban planning implementation strategies (Steiner, 2016:2).

Chapter 2 of the literature investigation commences with clarifying the urban ecology concept, followed with what urban ecological knowledge holds for urban planning practice and ultimately how to incorporate this urban ecological knowledge into urban planning practices. The final section of the Chapter considers the green infrastructure (GI) planning approach as the interface between urban ecology knowledge and urban planning practices.

2.3 Clarifying urban ecology for an urban planning audience

In an attempt for urban planners to comprehend the urban ecological discipline, key ecological concepts must be defined and interpreted for an urban planning audience (Cilliers & Cilliers, 2016: 8). Both Pickett and Cadenasso (2006:115), as well as Doulas (2010:3) suggest an approach that commence with the contrasting but interconnected concepts of “urban” and “ecology”. The concept of “urban” is without a doubt complex and flexible and cannot be limited to a singular definition (Pickett & Cadenasso, 2006:115; Adler & Tanner, 2013:4). Some authors claim that each research study may define a working definition of “urban”, that is explicit and according to their research purposes (Pickett & Cadenasso, 2006:115; Luedeitz *et al.*, 2015:101; Osmond & Pelleri, 2017:33). A “working definition” according to Harrison *et al.* (2014) is a definition “*created to understand a current phenomenon or concept but could change or evolve over time*”. For the purpose of this research **Box 1** explains the “working definition” for the concept of “urban” for this dissertation.

Box 1: Definition of “urban”

A spatial heterogeneous area, predominantly compromised of a mosaic landscape of anthropogenic surfaces (e.g., building surfaces and physical structures), and natural elements (e.g., natural habitats, natural resources, natural processes), along with the concentration of human activities regulated by different land-uses (e.g., residential, industrial, commercial, and recreational) with a noticeable high population density. Considered an oversight concept for cities, and suburbs, towns, townships, and informal settlements.

Source: Pickett and Cadenasso (2006:115); Feng and Tan (2017:43); Osmond and Pelleri (2017:33).

On the other hand, a generally accepted definition in the literature for “ecology” comprises of the following characteristics: (1) a science; (2) studying the interaction, distribution, abundance, and behaviour; (3) between organisms; and (4) their living environment (biotic) and non-living environment (abiotic) (Mcintyre *et al.*, 2008:7; Miller & Spoolman, 2011: 52; Barot *et al.*, 2019: 475). Alternatively, Sharma (2012:2) define “ecology” as “*the study of the function and structure of ecosystems*”. Ecosystems are accordingly defined as a community or a functional ecological unit of organisms (e.g., plants, animals, or microorganism) interacting with one another and with their physical environment (e.g., energy, water, soil, atmosphere, and temperature) (Miller & Spoolman, 2011:52; Osmond & Pelleri, 2017:31). It could therefore be said that “ecology” includes the study of environments, their context, and how living organisms live and interact within their environments or “ecosystems” (Steiner, 2016:2; McDonnell & MacGregor-Fors, 2016: 936). The Millennium Ecosystem Assessment (2005:31) identified some well-known natural ecosystems, including marine; coastal; inland water; forest; dryland; island; mountains; polar; and cultivated ecosystems. Other authors regard cities as ecosystems, or “urban ecosystems” (Grimm *et al.*, 2000: 574; Millennium Ecosystem Assessment, 2005:31; Richter & Welland, 2011:6; Forman, 2014:5; Osmond & Pelleri, 2017:31; Pickett *et al.*, 2016:3). Cities are unique urban ecosystems to investigate in the sense that they could be distinguished from the natural ecosystem in terms of certain attributes (Niemelä, 1999; Gómez-Baggethun & Barton, 2013:236; Grunewald *et al.*, 2018:2). Scott *et al.* (2016:280) acknowledges urban ecosystems as unique ecosystems as they are an ecosystem where anthropogenic and ecosystem functions and services overlap and interact within the same space. It is further recognised in the literature that humans are the dominant “designer” of urban ecosystems (Mcintyre *et al.*, 2000:6) and are characterised as “ecosystem engineers” that are responsible for actively modifying and maintaining urban ecosystems according to their specific goals, needs, and demands (Wu, 2008: 47; Adler & Tanner, 2013:3; Osmond & Pelleri, 2017:32). Gómez-Baggethun *et al.* (2013:178) claim that urban planning often recognises urban ecosystems as both the built infrastructure and the natural components within urban areas, while Pickett *et al.* (2001:128) claim that the green spaces in urban areas represent novel urban ecosystems. Humans depend fundamentally on these urban ecosystems for their benefits and their functions and services (urban ecosystem services will be discussed in detail in Chapter 4) that influence quality of life and urban health and well-being (MEA, 2005:9; Luederitz *et al.*, 2015:98).

The recognition of urban areas as being constituted by and including ecosystems led to questions regarding ecological studies within urban areas (Feng & Tan, 2017:43; McDonnell & MacGregor-Fors., 2016: 936). However, even though urban areas are considered as ecosystems or consist of spaces considered as ecosystems, ecosystems were merely studied within urban areas (Osmond & Pelleri, 2017:31). Urban ecosystems have only recently gained attention in the

relatively new “urban ecology” discipline (Alberti, 2008; Niemelä *et al.*, 2009; Pickett *et al.*, 2011:333; McPhearson *et al.*, 2016; Pickett *et al.*, 2016:1). A focus on studying ecology within urban areas was motivated by the following features:

- The impact of the urbanisation process, along with major population growth in developing countries – mainly Africa and Asia - and the reliance of people on ecosystems for natural resources and other benefits (Secretariat of the Convention on Biological Diversity, 2012:7).
- The increasing understanding that humans are a component of the earth's ecosystems and their interconnection with urban ecosystems (Grimm *et al.*, 2000:571).
- The fact that human activities are ever changing and shaping urban ecosystems according to their goals and preferences (Steiner, 2016: 109).
- As urbanisation contributes to climate change, a growing concern evolved about the resilience of 21st century cities (Wu, 2008: 41; Pickett *et al.*, 2016:1).
- Findings that urban areas are unsustainable, with consequences for both the natural environment and human health and well-being (Wu, 2008: 41).
- A general transition of the approaches and perspectives of the urban ecology discipline from ecology *in* cities to ecology *of* cities (Pickett *et al.*, 2016:1) and the more recent ecology *for* cities (an in-depth discussion on these perspectives follows in section 2.3.1).

In the following table (**Table 2-1**) some definitions regarding urban ecology proposed by different authors are provided.

Table 2-1: Definitions regarding the urban ecology concept.

AUTHOR	DEFINITION
Grimm <i>et al.</i> (2008:754)	Integrates the theory and methods of both natural and social sciences to study the patterns and processes of urban ecosystems.
Marzluff <i>et al.</i> (2008)	An interdisciplinary field that aims to understand how human and ecological processes could coexist in human-dominated environments, to guide societies with their efforts to become more sustainable.
Douglas (2011:3)	Urban ecology addresses the ‘human- natural environment’ relationship within an urban context.
McDonnall (2011:9)	Urban ecology integrates both basic (i.e., fundamental) and applied (i.e., problem oriented), natural and social science research to explore and elucidate the multiple dimensions of urban ecosystems.

AUTHOR	DEFINITION
Richter and Welland (2011:3)	Urban ecology provides valuable urban ecological knowledge about where and how urban ecosystems could be protected and improved in terms of urban environmental quality and physical human living conditions.
Forman (2014:3)	Urban ecology highlights all the spaces, not only parks and other greenspaces, but also the rich variety of built spaces.
Alberti (2016: 60)	The study of anthropocentric components along with their interaction with organisms in urbanised areas.

Source: Own construction based on Pickett and Cadenasso (2006); Grimm *et al.* (2008); Marzluff *et al.* (2008); Douglas (2011); McDonnall (2011); Richter and Welland (2011; Forman (2014); Alberti (2016).

Table 2-1 emphasis the fact that defining urban ecology according to a singular unifying definition is challenging. Sukopp (1998) claims that urban ecology has two definitions; one is comprised of scientific definitions, focusing on defining urban ecology similar to the definition of ecology of the distribution and abundance of biotic and abiotic factors within and around cities. Another explanation of urban ecology emerging from the urban planning discipline, defining urban ecology as an approach to design facilities and cities for humans, while reducing environmental degradation and therefore promoting sustainability (Sukopp, 1998; McDonnall, 2011:9).

Along with the different meanings related to urban ecology, perspectives on urban ecology also emerged, namely the ecology “*in*” cities perspective, the ecology “*of*” cities perspective, and more recently the ecology “*for*” cities. Each perspective contributes to different urban ecological characteristics and the application of ecological knowledge (Osmond & Pelleri, 2017:32). A further discussion on the different perspectives follows in the following section along with the application of these perspectives in urban planning practice.

2.3.1 Considering what urban ecological knowledge offers to urban planning decision-making and practices.

Urban ecology presents a general and applied scientific outlook and is therefore regarded as the foundation to bridge the gap between urban ecological scientific data and the practical implementation thereof (McDonnell & MacGregor-Fors, 2016:936). As previously mentioned, urban ecology as an evolving discipline has different perspectives, namely the *ecology in cities*, *the ecology of cities*, and more recently the *ecology for cities*.

The *ecology in cities* perspective for instance refers to the studying of only the non-human organisms' and their physical environment within and around urban environments (Wu, 2014:211; Osmond & Pelleri, 2017:32), for example soils, plants and vegetation, and animals and wildlife, substrate, climate (e.g., temperature), water, and air (Pickett *et al.*, 2001:130) with no integration with the social science (Wu, 2014). This perspective provides important scientific knowledge for urban planners regarding the biodiversity of urban areas (rare or endangered species) and available natural resource that require consideration (Pickett *et al.*, 2016:3). Within *ecology in cities* studies urban areas, and related human activities are studied as agents of distribution to ecological functions and conditions (Mcintyre *et al.*, 2000:6; Forman, 2014:3; McDonnell & MacGregor-Fors, 2016:936).

On the other hand, the *ecology of cities* perspective emphasis the entire city as an ecosystem with the focus on the balance between both social and biophysical processes (Grimm *et al.*, 2000:571; Wu, 2014:221; Osmond & Pelleri, 2017:32). The latter recognises that humans are incorporated as an integral component of the complex urban system and further emphasises the importance of biological or "natural" components of urban ecosystems to provide the necessary ecological functions and services to a city and its urban dwellers (Wu, 2008:4; Grunewald *et al.*, 2018:2). The essence of studying *ecology of cities* is to comprehend that the ecological process or the natural components of urban ecosystems provide several processes and functions to cities (e.g., habitat provision, biodiversity, hydrological functions, nutrient and mineral cycling, productivity) and these functions provide accompanied ecosystem services (ESs) and disservices. Ultimately, the *ecology of cities* perspective emphasises humans and their dependence on urban ecosystems and their functions to contribute to human health and well-being, as well as to support sustainable cities (Cilliers *et al.*, 2014:264; Luederitz *et al.*, 2015:98).

However, ecological knowledge alone does not provide practitioners with the necessary information (Niemelä, 1999:127). Therefore, more recently Childers *et al.* (2015:3779) drew attention to the moving from *ecology of cities* to *ecology for cities*, with the focus on a more **applied outlook** on urban ecological knowledge (McDonnell & MacGregor-Fors. 2016:936). Also referred to by Pickett *et al.* (2016:5) as "knowledge-to-action" based research. The foundation of an *ecology for cities* perspective is grounded in a transdisciplinary approach (McPearson *et al.*, 2016:202) implying the co-production and synthesis of knowledge (Ahern *et al.*, 2014:255). The transdisciplinary outlook of the approach involves urban scientist, such as urban ecologists, designers, planners, engineers, (Childers *et al.*, 2015:3779), as well as civic society (local communities) to joint and collaborate with research and knowledge in pursuit of sustainable urban futures (Pickett *et al.*, 2016:5). Moreover, *the ecology for cities* approach entails a more holistic science of cities (McPearson *et al.*, 2016:202). The approach is holistic in the

sense that it follows a participatory process, integrating different research in practice between scientists, planning professionals, and among all of the human stakeholders in the urban ecosystem (McPearson *et al.*, 2016:202). The primary aim of such an approach is to build on the previous approaches (*ecology in cities* and *ecology of cities*) and to transform the gathered ecological research and knowledge into action-based practices (Childers *et al.*, 2015:3785). Ultimately, *ecology for cities* and its transdisciplinary and holistic manner enhances the application of links between urban ecological knowledge and urban planning and design (Tan, 2017:24). Van den Bosch & Sang (2017: 373) claim an overarching concept may be coined as the incorporation of “nature-based solutions” (NBS) into urban planning related practice. The International Union for Conservation of Nature (IUNC) considers NBS as approaches utilising ecological knowledge to provide human well-being and biodiversity benefits to urban areas (IUNC, 2020). NBS could also be defined as “*approaches that are inspired by or copied from nature*” (van den Bosch & Sang, 2017: 373).

Conceptually, NBS in urban planning practice might be considered as an “ecological turn” in planning activities (Fastenrath *et al.*, 2020:64). The literature suggests the application of NBS as the implementation of Green Infrastructure (GI); ecosystem-based management and adaption; and Ecosystem Services (ESs) (van den Bosch & Sang, 2017:373) ensuring benefits to both human health and well-being, as well as for biodiversity and environmental performance within urban areas (Raymond *et al.*, 2017:20). The NBS concept which is, according to Pauleit *et al.* (2017:47), rooted in urban planning practice is the concept of green infrastructure (GI). Mell (2013:159) observes that the role GI holds for urban planning practice is the ability to incorporate ecological knowledge within urban planning activities. More details on the GI concept will follow in the following section of the chapter.

2.4 Considering the Green Infrastructure planning approach as the interface between urban ecology knowledge and urban planning practices

The GI concept has been acknowledged in the literature as a conceptual tool for urban planning practice (Hansen & Pauleit, 2014; Pauleit *et al.*, 2017:47). The approach is accordingly considered as a critical connection between the environment and urban planning practices to improve the quality of life, quality of space and the quality of the urban environment (Mell, 2010:255).

The literature presents numerous, critical, and divergent definitions of GI (Benedict & McMahon, 2006:1; Davies *et al.*, 2006). Several attempts have been made to define GI and according to Mell (2010:33) there “*are as many definitions of GI as authors working on the concept*”. Consequently, the concept is broad and interpreted depending on the sector and context within which the concept is employed (Benedict & McMahon, 2006:1; Wright, 2011:1007). Lennon and Scott

(2014b:3) suggest that a GI definition for urban planning purposes should cover both social and ecological issues and refer to the GI definition as proposed by Benedict and McMahon (2006:1). The definition of Benedict and McMahon (2006) has also been widely adopted in the ecological field (Young *et al.*, 2014:2517) and define GI as “*cities natural life-support system that consist of an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions (ecological perspective) ... and provides a wide array of social, economic, and health benefits for people (social perspective)*”. Lindholm (2017:610) reflects on the definition presented by Benedict and McMahon (2006:1) and claims that over the years an overall change occurred in context of the definition of Benedict and McMahon (2006). The more recent trends in defining GI refer to the “*design and management of ecosystems to deliver a wide range of ecosystem services*” (Lindholm, 2017:610). In many cases the concept of GI is complimented with the NBS concept including - ecosystem services (ESs) (Kabisch *et al.*, 2016:39). It was pointed out by literature that GI provides effective ESs that are expensive and difficult to replace with man-made solutions (Molla, 2015:97).

Broadly speaking, ESs include the benefits urban ecosystems deliver to improve human health and well-being (Hansen *et al.*, 2017:5). Both Pauleit *et al.* (2011:272) and Hansen and Pauleit (2014) recognise GI to provide multiple ESs. **Figure 2-2** provides a short summary of ESs that divided by the literature into four ESs categories, namely provisional, regulating, cultural, and habitat and supporting services (Chapter 4 of the study elaborates on an in-depth discussion regarding the ESs).

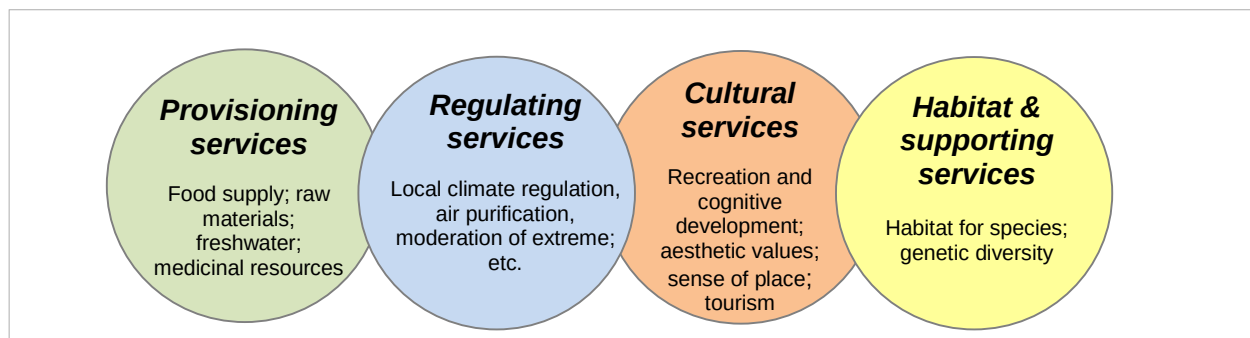


Figure 2-2: Four categories of ecosystem services with their sub-divisions.

Source: Own construction based on MA (2005) and TEEB (2010).

Considering **Figure 2-2**, as well as other definitions within the literature regarding GI, **Box 2** illustrates a definition of GI for the purpose of this research dissertation.

Box 2: A definition for the concept of green infrastructure (GI)

An interconnected network within an urban area, consisting of a broad range of environmental features (including all natural, semi-natural and artificial green spaces and blue spaces) planned, design and

Box 2: A definition for the concept of green infrastructure (GI)

managed to conserve ecosystem functions, contributing to biodiversity conservation, and providing benefits (*social, economic, and health benefits*) to humans by delivering multiple ecosystem services.

Source: Benedict and McMahon (2002); Benedict and McMahon (2006); Cilliers and Cilliers (2016).

The definition illustrated in **Box 2** will be applied throughout this study.

Seeing that green space is a broad term classified according to different mechanisms Taylor and Hochuli (2017:30) suggest that scholars clarify what the term “green space” suggests in the context of a specific research study. For this study, “green spaces” refer to all the elements that are classified under the concept of GI, as illustrated in **Box 2**. In the following section follows a discussion on green spaces as part of the broader GI concept.

2.4.1 Considering green spaces as Green Infrastructure elements and a part of the broader Green Infrastructure concept

Several different classification mechanisms and definitions regarding green spaces are recognised within the literature (Cilliers *et al.*, 2013:683; Cvejić *et al.*, 2015:9). In the urban planning discipline, some scholars refer to green spaces as “open spaces”, “urban green space”, and “green environments” (Taylor & Hochuli, 2017:25; Boulton *et al.*, 2018:84). In a South African context “green spaces” and “open spaces” are often used complementarily (Cilliers & Cilliers, 2016:9).

An open space is accordingly classified as open land with no building or structure and is generally accessible to the public (EPA, 2013). This space could be predominately comprised of formal open spaces or “developed” open spaces that include “hard surface” civic spaces, for instance, squares, playgrounds, public plazas, and paved areas (Dunnett *et al.*, 2002:8) or informal undeveloped open spaces that demand less maintenance and costs, for example vacant land (City of Tshwane, 2005: v; Scottish government, 2011:13; EPA, 2013). Open spaces contribute to the amenity of urban areas by including a broad range of aesthetically pleasing benefits (EPA, 2013) or enhanced ecological functions (Dunnett *et al.*, 2002:8). Not all open spaces can be classified as “green spaces”, however, some open spaces may include green space (EPA, 2013). Open spaces are predominantly composed of “soft vegetated surfaces” are recognise as green spaces, or for instance open spaces with surfaces mainly of soil, grass, and shrubs, including bushland, nature reserves or national parks (Dunnett *et al.*, 2002:8; Schäffler & Swilling, 2013:247; Papageorgiou & Gemenetzi, 2018:86). These open spaces are often the remnants of existing pristine nature areas in the urban matrix (Müller *et al.*, 2010:3; Planchuelo *et al.*, 2020:1) or the fragmented patches of natural habitats leftover in urban areas (Lindley *et al.*, 2018:338).

Natural remnants could represent, for instance, natural and restored native ecosystems (Benedict & McMahon, 2006:7), naturally occurring or rehabilitated vegetation cover of local biomes (a unit of similar vegetation structure) (Shanahan *et al.*, 2015: 155), as well as leftover of primeval forests, or traditional agricultural land, for instance meadows and areas of arable land (Müller *et al.*, 2010:3). Furthermore, remnants of existing nature could also include water-based environments such as remnant ponds (Holzer, 2014:956), natural wetlands (Childers, 2015: 3778) and linear surface water such as natural canals, streams, and rivers (Haeffner *et al.*, 2017:136). Taylor and Hochuli (2017:25) recognise this view of green spaces as a “*green spaces as nature*” perspective.

The second interpretation of green space refers to “*green space as urban vegetated space*”. This is according to Taylor and Hochuli (2017:25) seeing the fact that green spaces are not always predominated remnants of existing nature or ecosystems, they could also be other urban land-uses as artificially developed green areas (Shackleton *et al.*, 2018:273). Colding (2011:232) regards these green spaces with a high degree of human influence for instance parks, golf courses, botanical gardens, street trees, school grounds, sports fields and other green spaces intended for recreational use (Thaiutsa *et al.*, 2008:220; McConnachie & Shackleton, 2010:250; Schäffler & Swilling, 2013:247). These green spaces are often understood as being directly utilised for their recreational characteristics and indirectly for their positive environmental contributions (Grunewald *et al.*, 2017:26). In line with the GI definition illustrated in **Box 2**, Mell (2011:15) claims all green spaces, for instance the above-discussed “*green spaces as nature*” as well as the human-made “*green space as urban vegetated space*” as *elements* of the broader GI of urban areas.

In addition to the above-discussed green spaces, Hansen *et al.* (2017:32) further acknowledged that green spaces could also include “green resources”, such as vegetation, combined with engineered technical structures or combined with urban infrastructures (“grey” infrastructure), for example, buildings transport, communication, water supply, and wastewater systems (Pauleit *et al.*, 2011:272) to create green infrastructure elements such as allotment gardens, roof gardens, rain gardens, bioswales, constructed wetlands, mobile backyard gardens or different forms of guerrilla gardening (Mell, 2013:153; Hansen *et al.*, 2017:9). These GI elements are equally essential as the traditional urban grey infrastructure as they could provide infrastructure functions such as flood protection and water purification, as well as other necessary ecosystem services (Benedict & McMahon, 2002). Bobbins and Culwick (2015) agree with this interpretation of GI elements and classify these GI elements as “grey-green design” solutions, or in other words when traditional grey infrastructure (engineered structures) incorporate green resources as a

collaborator to be more environmentally friendly, as also indicated by Benedict and McMahon (2006:5).

The above discussed interpretation of GI elements was explained and illustrated by Davies *et al.* (2006:3) in their “green-grey continuum” (**Figure 2-3**). The figure illustrates that GI includes elements that are visually or functionally “green” (the green spaces as nature perspective), as well as those elements that are classified as “green infrastructure” even if the primary land use of the elements is not exclusively classified as visually “green” (the grey-green design solutions) (Davies *et al.*, 2006:3).

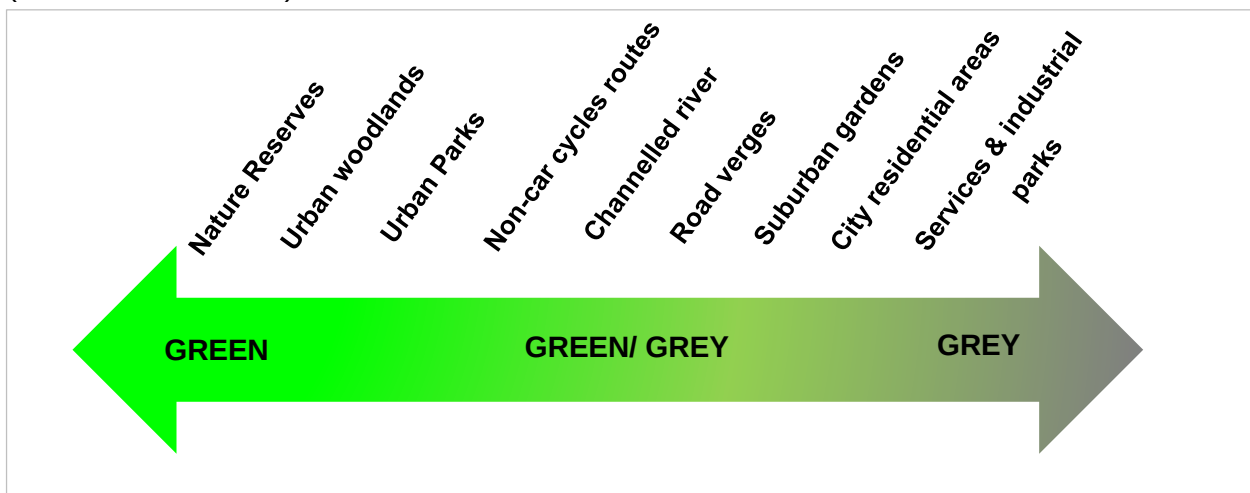


Figure 2-3: The “grey-green interpretation”.

Source: Own construction based on Davies *et al.* (2006).

According to Cilliers (2009:183) the green-grey continuum (**Figure 2-3**) could provide urban planners with a more balanced view regarding “green” infrastructure elements in contrast to traditional grey infrastructure.

Both Wright (2011:1016) and Lennon and Scott (2014b:3) however claim that urban planners should not be limited solely to “*what GI is*”. Instead, Wright (2011:1016) suggests that urban planning requires a consideration of the question “*what GI planning intends to address?*” to provide a more suitable meaning of GI to the planning practice. Bobbins and Culwick (2015:39) acknowledge that the purpose of GI planning is to “*incorporate services provided by natural urban assets (ecosystems) and other green spaces into the planning of cities*”. In this regard, Davies *et al.* (2017) considers GI as a “*biophysical concept*”, and the application of biotic and abiotic aspects in spatial planning activities. From another standpoint, Hansen *et al.* (2017:1) consider GI planning as “*a strategic planning approach that aims to develop networks of green and blue spaces in urban areas, designed and managed to deliver a wide range of ecosystem services and other benefits at all spatial scales*”. The following section considers GI in urban planning practice in more detail.

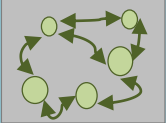
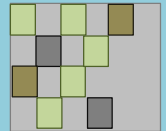
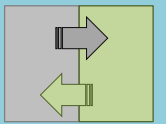
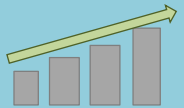
2.4.2 Contextualising Green Infrastructure as a spatial planning approach

According to Benedict and McMahon (2002:12) planning for GI in urban planning practice differs from traditional conservational green space planning. GI planning aims for a more holistic and higher quality approach to the planning of green spaces, as well as the human-nature relationship within urban areas (Wright, 2011:1016). Therefore, Pauleit *et al.* (2011:273) emphasise that GI planning cannot be limited to one definition nor to one approach, however, planning for GI is based on a number of spatial planning principles that require consideration (Pauleit *et al.*, 2017:47).

2.4.2.1 Spatial planning principles to consider when planning for GI.

According to Mell (2013) and Pauleit *et al.* (2011) GI planning is underlined by the spatial principles of, “connectivity and networks”, “multi-functionality”, “integration” (of people, places, and policies), “social inclusion”, and the principle of “long-term strategies” (Davies *et al.*, 2006:14; Madureira & Andersen, 2014). **Table 2-2** elaborates on these five principles to consider when planning for GI.

Table 2-2: GI planning principles and the role of urban planning for each principle.

GI PLANNING PRINCIPLE	DESCRIPTION	THE ROLE OF URBAN PLANNING
Connectivity 	Enhancement of movement and flow of both humans and wildlife by creating strategic interlinks between ecosystem elements (green spaces). Could refer to both structural and functional connectivity. The latter refers to the consideration of patterns of movement and behaviour of wildlife, while structural connectivity focus on the physical connection between spaces.	- Consider both physical and functional connections on different scales, for instance both social and abiotic movements between green spaces. - Focus on context-based planning through analysis of the resources and functions of the green spaces in the specific area.
Multi-functionality 	Planning for the intertwining or combining of different functions to enhance the capability of GI to deliver multiple environmental, economic, and social benefits, or in other words the ecosystem services. Could be applied to a single site (green spaces) or between the connected GI elements.	- To consider different categories of ESs. - An emphasis on improving positive synergies between the multiple ecological, socio-cultural, and economic benefits concurrently. - Improve awareness regarding multi-functionality through communication and education. - Prioritise functions in relation to who needs them and who has access to them. - Requires a strong element of public participation.
Integration 	The physical and functional synergies between GI and other urban (grey) infrastructure. The aim is not only to fulfil primary infrastructure needs, but also to provide wider environmental, social, and economic benefits.	- Consider the integration and coordination of green space with other urban infrastructure, for example transport systems or water systems. - Incorporate collaboration along with knowledge from different disciplines, professionals, and other actors.
Social inclusion 	Part of the process of planning for GI is to include a variety of private and governmental stakeholders, other disciplines as well as the civil society (different social and cultural groups) through especially considering their preferences, concerns and needs regarding green spaces.	- Attempt to consider the needs and interests of all involved stakeholders. - Involve the different stakeholders in decision-making through coordination and collaboration on different levels of participation, for example between the public- and private sectors, as well as public participation.
Long-term strategy 	GI planning requires long term strategies while focusing on multiple ongoing uses and the continuous involvement of different stakeholders to achieve final goals.	- To consider the sustainability concept to long-term development benefits. - To allow for “learning by doing” or adaptive planning.

Source: Own construction based on Pauleit *et al.* (2011); Lennon *et al.* (2016); and Hansen *et al.* (2017).

Davies *et al.* (2006) provide a word of caution when attempting to plan for quality GI. The authors claim that planners require a conceptual understanding, as well as knowledge pertaining to the *multi-functionality* principle, as discussed in **Table 2-3** (Davies *et al.*, 2006). The principle of multi-functionality aims to create a positive synergy between both humans and natural components through spatial planning (Lennon & Scott, 2014b:3). According to Hansen and Pauleit (2014:525) seeing the fact that the principle of multi-functionality focusses on urban areas as interacting social-ecological systems it could be associated with an ecological approach towards planning. However, literature claims this principle is often overlooked by urban planners (Di Marino *et al.*, 2019:644), mainly framing it as an elusive and poorly conceived concept. Also, recent work by Hansen *et al.* (2017:43) theorises that there seems to be uncertainty regarding the context and application of the multi-functionality principle among planners. Accordingly, the principle of multi-functionality within urban planning practice presents the opportunity to be studied and will be further investigated in Chapter 5 of the study.

Alongside the spatial planning principles to consider when planning for GI, GI planning could also be implemented differently according to different planning strategies and spatial scales employed (Lennon & Scott, 2014a: 579). A discussion of the planning strategies and spatial scales follow.

2.4.2.2 Spatial planning strategies and different spatial scales of GI planning

Ahern (1995, 2007) offers planning strategies for planning practitioners when involved in GI planning. Ahern (2007:281) proposes the strategies of “*protective*”, “*defensive*”, “*offensive*” and “*opportunistic*” GI planning. The strategies, along with practical examples of how the strategies could be applied in spatial planning are discussed in the subsequent table, **Table 2-3**.

Table 2-3: Planning strategies for green infrastructure planning.

PLANNING STRATEGY	DESCRIPTION	PRACTICAL EXAMPLES
Protective	Employing preventative actions to preserve existing GI elements (green spaces) and functions (ecosystem functions and services) before they are threatened or changed by development.	- Planning for world heritage sites, national parks, and nature conservation areas by employing land-use zonings. - Planning greenbelts and corridor designation.
Defensive	Implementing measures to defend GI elements and functions that are under development constraints and pressure.	- Creating buffer zones. - Environmental impact mitigation strategies. - Formulation of green space standards.

PLANNING STRATEGY	DESCRIPTION	PRACTICAL EXAMPLES
Opportunistic	Recognising the potential for non-contributing aspects to be managed or structured to enhance the elements and function of a GI network.	- Enhancement of biodiversity planning initiatives. - Implementing greenway projects. - Considering urban greening initiatives. - Incorporation of a GI plan.
Offensive	Taking remedial or restorative actions to repair, replace or restore GI elements and functions.	- Environmental adaption initiatives. - Reintroduce ecosystem service categories where they do not currently exist. - Enhance or provide access to existing green spaces.

Source: Own construction based on Ahern (1997, 2007) and Lennon and Scott (2014a).

Upon studying **Table 2-3**, it could be recognised that GI planning includes not only the safeguarding of existing green spaces, but also the enhancement and restoration of GI elements (Lennon *et al.*, 2016:850). Moreover, when considering an “offensive” spatial planning strategy, new elements could be plan for and created through planning for new GI elements (Lennon *et al.*, 2016:850; Daniels *et al.*, 2018: 1365). According to Ahern (1995:140) the goal of an offensive strategy involves “*putting nature back into the urban landscape*”. Mell (2011:89) recognises that planning these “new” elements could occur at different scales (Mell, 2011:89).

Davies *et al.* (2006:11) propose that planning for GI could occur at three spatial levels. **Figure 2-4** illustrates the three spatial levels as the 1) local level, the 2) second level as the neighbourhood or city level, and 3) the highest level as the regional level

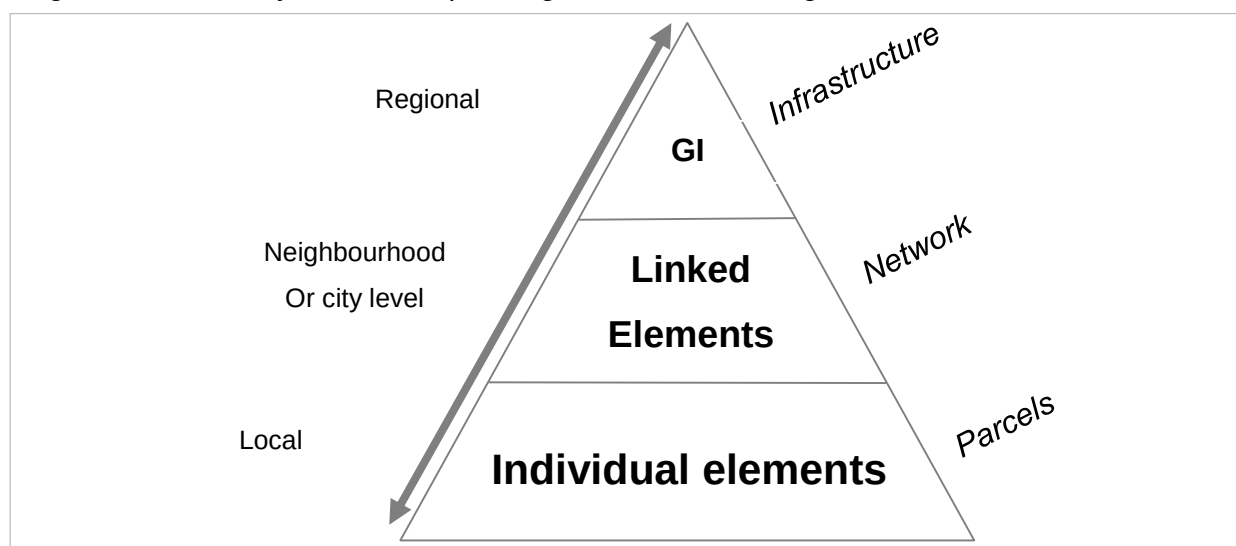


Figure 2-4: Different spatial levels of Green Infrastructure planning.

Source: Own construction based on Hansen and Pauleit (2014).

When studying **Figure 2-4**, the local level represents the basic spatial elements or the parcels of GI. These GI parcels include a broad spectrum of types of green and blue elements, as discussed

in section 2.4.1, for instance, nature reserves, parks, sports fields, wetlands, allotments, cemeteries, community and domestic gardens, vacant land, and all kinds of water bodies, as well as other man-made green spaces (Ahern, 2007:271; Hansen & Pauleit, 2014:520; Hansen *et al.*, 2017:15). The second spatial level occurs at a neighbourhood or a city level and considers the GI elements (as discussed above) along with the connectivity principle (c.f. Table 2-2) between the GI elements to form a GI network (Hansen & Pauleit, 2014: 520). The highest spatial level of the pyramid in **Figure 2-4** includes the previous level – the network of GI elements - on a regional scale (Hansen & Pauleit, 2014: 520).

Bolund and Hunhammar (1999:297), as well as Anderson *et al.* (2016:446) emphasise the focus on the local level GI elements, as these spaces generate easily accessed ESs used by a greater variety of urban dwellers to improve their quality of life. It is for the same reason that The Scottish Government (2011:1) recognises that these local level elements of GI could serve a useful GI purpose. GI elements are however extremely diverse with several classifications in the literature (Cvejić *et al.*, 2015:9). According to Mell (2011:17), in order to apply GI planning in practice an examination should first be made of *what GI actually constitutes of*, or in other words what GI elements are possible for implementation (Mell, 2011:17).

2.5 Conclusion

The primary aim of Chapter 2 was to address the first research objective on the interface between urban planning and urban ecology to build on the case for an ecological approach in urban planning. The chapter underlined the importance of urban ecology as applied science to the urban planning practice. Findings indicated a transdisciplinary and holistic manner is required for applying such urban ecological knowledge into mainstream urban planning practices. Taken together it is suggested that a holistic approach is required to integrate urban ecology within urban planning practices through the GI planning approach. The GI planning approach presents the ability for urban planning to directly consider and incorporate urban ecological knowledge into mainstream urban planning practice. In essence, Chapter 2 served as a prelude to the subsequent chapters of the literature study that will further build on the case for an ecological approach in urban planning practice. Therefore, the following chapters will further investigate GI and the ecological aspects and concepts of ESs and multi-functionality as components of the GI planning approach and as means towards an ecological approach for urban planning practice. In the following chapter, GI is further explored by considering typologies of GI.

CHAPTER 3 – OUTLINING GREEN INFRASTRUCTURE TYPOLOGIES

3.1 The structure of the Chapter

Figure 3-1 illustrates the structure of Chapter 3.

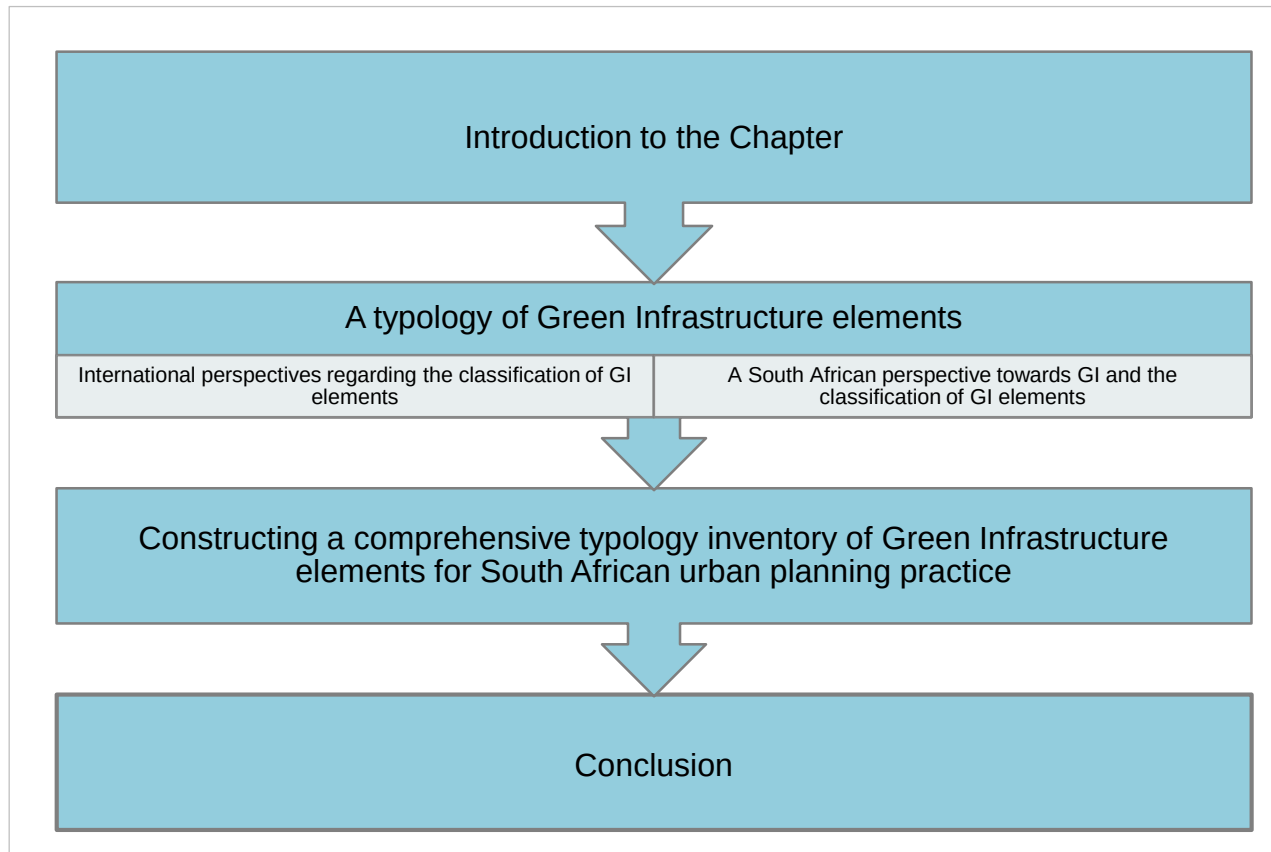


Figure 3-1: Structure of Chapter 3.

Source: Own construction (2020).

3.2 Introduction to the Chapter

As seen in the previous literature investigation Chapter, green spaces as elements of a city's green infrastructure (GI) are extremely diverse with several classifications ranging from parks to conservational areas, green roofs to urban agriculture, and also blue spaces such as lakes or rivers and other engineered and structured green spaces (Cilliers *et al.*, 2013:683; Cvejić *et al.*, 2015:9). Koc *et al.* (2017:15) claims that studies classifying GI elements are more scarce than studies defining GI. According to Hansen *et al.* (2017:31) a typology of GI elements is essential as the typology could be useful to communicate ecosystem services (ESs) provided by the GI to urban planners and other decision-makers. As seen in the research problem statement (c.f. 1.2) comprehensive GI element typologies are lacking in the South African context. Consequently, planners are unaware of the different types of GI elements possible for implementation (Cilliers & Cilliers, 2016:10). Therefore, this chapter will outline the typologies of GI according to various

international and local authors (South African) in order to compose a comprehensive typology inventory of GI elements. The study will use both the term green infrastructure (GI) elements and green spaces or open spaces interchangeably depending on the term employed by authors in their papers.

3.3 Typologies of Green Infrastructure elements

A “typology” is described as an attempt to develop a classification of categories of a phenomenon for some purpose (Dunnett *et al.*, 2002:9). A typology of green spaces is explained by Cilliers (2015:83) as an attempt to determine different green space categories possible for implementation in urban planning practice. Green spaces are applied at multiple scales and their access and functions could vary (Taylor & Hochuli, 2017:25). Therefore, there are various ways to classify green space, for instance according to size and scale, intended function, location, or surface coverage (Byrne *et al.*, 2010:10). There is no universal typology for green spaces, as a single typology cannot cover all the natural conditions (geomorphological, climatic, and biological), historical backgrounds, and social demands presented in different contexts (Cvejić *et al.*, 2015:9:10; Koc *et al.*, 2017:32). Yet, the literature presents several attempts to develop GI typologies from an academically driven process, field research, or synergy of existing data (Young *et al.*, 2014:2573). The following section will outline some of the GI elements (green space) typologies presented in international literature. The second part of this section will reflect on a South African perspective regarding GI planning, green spaces and typologies developed for the South African context.

3.3.1 International perspectives regarding the classification of green infrastructure elements

Young *et al.* (2014) reflected on the typologies of GI elements developed by several authors. Some of the authors mentioned by Young *et al.* (2014) include Ahern (1995), Dunnett *et al.* (2002), and Davies *et al.*’s (2006). Ahern (1995) studied “greenways”, referring to a linear network of GI in the United States and Netherlands. The GI typology of Ahern (1995) was solely based on greenways and the issues of scale, goals, landscape context, and planning strategy regarding the greenways (Ahern, 1995:137-139). Young *et al.* (2014:2573) acknowledge Ahern’s typology as a useful typology to identify and categorise the networks and linear elements of the complete GI system. Alternatively, Dunnett *et al.*’s (2002:9) typology reflects a range of public and privately owned types of green spaces that together form the green fabric of the urban area. These green spaces are divided into four main categories, namely: amenity green space, functional green space, semi-natural habitats, and linear green space, including 26 subcategories (refer to **Table 3-1**) (Dunnett *et al.*, 2002:9). On the other hand, the typology of Davies *et al.* (2006) was guided by the “Green Infrastructure Planning Guide” developed for Northeast England. According to

Davies *et al.* (2006) the purpose of their typology is to represent a “*more informed and systematic way to consider and prioritise green infrastructure within the spatial planning process*”. Their typology is included in **Table 3-1**.

In 2017 Koc *et al.* (2017) also conducted a literature review of 85 articles on the classification of GI elements by different authors. The study also reflected on the typologies of Ahern (1995), Dunnett *et al.* (2002), Davies *et al.* (2006), as well as numerous other authors. The preliminary analysis of the 85 articles indicated that elements of GI depend on the terminology and definitions regarding GI employed at different studies. The study of Koc *et al.* (2017) detected overlapping terminology and grouped GI elements into four main categories of (a) tree canopy; (b) green open spaces; (c) green roofs; and (d) vertical greenery systems (Koc *et al.*, 2017:29). These categories, as well as examples of their GI elements are summarised in **Table 3-1**.

Furthermore, Koc *et al.* (2017) also found that the literature regarding GI typologies was predominantly from the UK and European countries based on government reports and guidelines (Koc *et al.*, 2017:29). Some of Koc *et al.*'s (2017) findings regarding the most suggested classifications from the UK, included the Mersey Forest approach by the Landscape Institute (2009) and the green spaces typology of England (PPG 17) developed by The Urban Green Spaces Taskforce (Shi & Woolley, 2014:5). The England (PPG 17) typology included a typology of green space elements of the whole urban area, as well as the urban fringe. Furthermore, the typology including other “hard surface” open spaces such as squares, pedestrian areas and cycling areas (Shi & Woolley, 2014:5; Cvejić *et al.*, 2015:9) (refer to **Table 3-1** for The Urban Green Spaces Taskforce green space typology).

The Landscape Institute (2009:4) classified GI elements as all “*natural elements providing social, environmental, or economic benefits*”. As the elements could vary from a specific site to a broad environmental feature, the Landscape Institute believes a useful approach is to classify the elements according to their spatial scale where each element would typically be found (Landscape Institute, 2009:4). The spatial scales include 1) Local, neighbourhood and village scale Town, city, and district-scale City-region, regional and national scale; 2) Town, city, and district-scale: Business settings; and 3) City-region, regional and national scale (Landscape Institute, 2009:4). Each of these spatial scales and their accompanied GI elements are included in **Table 3-1**.

Another GI typology that was investigated for the purpose of this study was the typology proposed by The Scottish Government (2011). Their typology focuses on “grey-green designs” as discussed by previous authors (Davies *et al.*, 2006; Bobbins & Culwick, 2015) (c.f. section 2.5.1). In line with this, The Scottish government considers GI elements not just as physically green spaces, but also

incorporates natural remnant “blue spaces” including wetlands, rivers and canals, and their banks, and other watercourses (The Scottish government (2011:1). **Table 3-1** also captures the typology of GI elements as proposed by The Scottish government (2011).

Mell (2010:39), employed Ahern’s (1995) typology as a foundation for a “refined typology for GI” and suggests three typology classifications to GI elements, namely, form, function, and context (see **Table 3-1**). Mell’s (2010) typology has similarities to the typology of Ahern (1995) in terms of “landscape functions” and both typologies focus on the physical “form” of GI. According to Koc *et al.* (2017:19), “*form*” refers to the “*physical characteristics of the elements*” and “*function*” as the “*processes and services*” provided by the elements.

Benedict and McMahon (2002:7) comprehended GI elements in a similar manner to Mell (2010) according to the “function” classification. According to Benedict and McMahon (2002:12) all GI elements consist of natural and restored ecosystems (the natural remnants identified and discussed in section 2.3) that are as seen in **Figure 3-2** either classified as “hubs” or “links”.

The “hubs” in **Figure 3-2** are classified as the “anchor” of a GI network, providing biodiversity and habitats for ecological processes (Benedict & McMahon, 2002:12). According to Eisenman (2013:298) hubs vary in shape and size. Therefore, a “hub” could include any of the following elements (Benedict & McMahon, 2002:13; Eisenman, 2013:298; Mejía *et al.*, 2015:528):

- **Large parks and reserves**, for example, nature reserves or national parks of conservation value or wildlife resorts.
- **Working lands**, for example, privately owned farms and forests employed for production purposes.
- **Recreational parks and others natural areas**, for example, smaller parks or remnant natural areas, consequently providing important ecological and social values, such as habitats and a space for nature-based recreation.

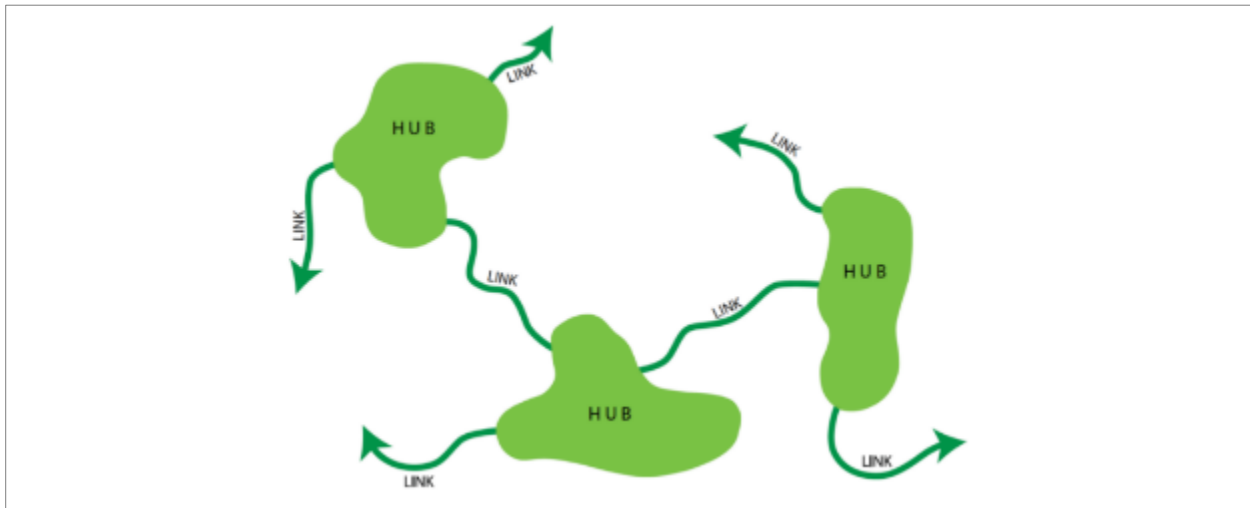


Figure 3-2: Conceptual Green Infrastructure network.

Source: Adapted from Eisenman (2013).

On the other hand, the “links” shown in **Figure 3-2** have characteristics of linear vegetated features that act as connectors between the hubs and together develop a GI network (Benedict & McMahon, 2002:12). Links serve as important connections and corridors that are essential to the maintenance of ecological processes. Links, similar to hubs, differ in function, shape, and size (Eisenman, 2013:298) and could comprise of:

- **Landscape linkages**, for example large protected natural corridors connecting large parks and reserves and at the same time providing space for the movements of plants, animals, and people.
- **Conservation corridors**, for example rivers, stream floodplains and forested corridors acting as biological canals and providing opportunities for outdoor recreational activities.
- **Greenways and greenbelts**, function as protective corridors for resource conservation or to preserve native ecosystems and agricultural (working) lands.
- **Eco-belts**, functioning as a buffer zone between urban and rural areas and at the same time providing ecological and social benefits for both urban and rural residents. (Benedict & McMahon, 2006:7; Mejía *et al.*, 2015:528).

Whereas urban green spaces are often considered a luxury in developing countries (Cilliers & Cilliers, 2016:22), Benedict and McMahon (2006:7) emphasise “hubs” and “linkages” as something urban areas require in order to protect and restore natural life-supporting systems. A gap in the typology of Benedict and McMahon (2002, 2006) is the inclusion of the grey-green design elements that constitute an important part of the broader GI network (Davies *et al.*, 2006:3).

The GREEN SURGE project report (2013-2017) developed a comprehensive inventory of urban green space elements to comprehend how green spaces could function as GI elements (Cvejić

et al., 2015:9). The report reflects on European perspectives and therefore investigated existing inventories, literature, and case studies on urban green space from different European cities (Cvejić *et al.*, 2015:9). The identified list of green space elements is grouped into eight broader categories based on scale, location within city, and function (refer to **Table 3-1**).

The significance of the list of urban green spaces proposed by the GREEN SURGE project is that the list includes comprehensive elements (both green and grey elements) as proposed by Davies *et al.* (2006) employing the grey-green continuum (c.f. Figure 2-3). Their typology also specifically includes those natural elements (ecosystems) usually not considered as elements in urban areas (as proposed by Benedict & McMahon, 2002 & 2006) for instance arable land, forests, biomes, and blue spaces (e.g., waters, wetlands) (Cvejić *et al.*, 2015:14).

In addition, an unfamiliar classification or often overlooked typology of GI elements are the typology of Rupperecht *et al.* (2015) on a variety of “non-traditional green space” or informal green spaces (IGS). The typology of Rupperecht *et al.* (2015) on IGS is also included in **Table 3-1** and distinguishes between nine (but not exclusive) categories of IGS. Ruppercht (2017:59) claims these IGSs are still an understudied field and require more research regarding the perceptions, usage, and management thereof.

In essence, this section of Chapter 3 reflected on different international perspectives regarding typologies of GI elements. The purpose of **Table 3-1** is to capture comprehensive typologies regarding GI elements processed by different international authors. Therefore, the table includes typologies proposed by some of the international authors discussed above (Dunnett *et al.*, 2002; Landscape Institute, 2002; Benedict & McMahon, 2006; Davies *et al.*, 2006; Mell, 2010; The Scottish government, 2011; Ruppercht & Byrne, 2014; Cvejić *et al.*, 2015; Koc *et al.*, 2017).

Table 3-1: Green infrastructure typologies based on international perspectives.

Authors	The Scottish government (2011)	Dunnett <i>et al.</i> (2002, 2003)	Koc <i>et al.</i> (2017)
Classification approach	Scale-based	Based on usage	Based on GI terminologies and definitions
Typologies	Building scale (home, garden, or workspace): Green roofs; Living walls; Gardens or grounds; Rainwater harvesting systems; Driveways (permeable) Street scale: Boundary features (hedges); Street trees; Swales; Porous paving Neighbourhood scale: Informal recreation spaces; Play spaces; community growing spaces; Sports fields; parks; Burial grounds, cemeteries; woodlands; Water bodies. Strategic places: Civic scale space; public parks and gardens; green networks; forests; grasslands; designed landscapes; rivers; wetlands	Amenity Green Space: <i>Recreation Green Space</i> - Parks and Gardens; Informal Recreation; Areas Outdoor; Sports Areas; Play Areas. <i>Incidental Green Space</i> - Housing Green Space; Other Incidental Space <i>Private Green Space</i> - Domestic Gardens) Functional green: <i>Productive green space</i>- city farms; allotments <i>Burial grounds</i> - Cemeteries; churchyards), <i>Institutional grounds</i> (School grounds and growing areas Semi-natural: <i>Wetland</i> - Open/ running water; marsh, fen) <i>Woodland</i> - Deciduous; coniferous and mixed woodland <i>Other habitats</i> -Moor/ heath, grassland, disturbed ground. Linear green: River and canal banks; transport Corridors; other linear features e.g., cliffs.	Tree canopy: Green canopy; Green streets; Green alleys (Street); Trees Shrubs, shrubbery; Tree cover; Urban forestry; Urban tree canopy; Woodland (Forest) land. Green open spaces: Green belts; Green corridors; Green covers; Greenspaces; Greenways; Vegetated Ground covers; Ground surfaces Land covers; Public and urban open spaces; Urban land; Urban vegetation structures; Vegetative covers. Green roofs: Eco-roofs; Green rooftops; Living roofs; Rooftop gardens. Vertical greenery systems: Bio-walls; Green façades; Green walls; Living walls; Vertical landscaping; Vertical vegetation.

Table 3-1 continues.

Authors	Landscape Institute (2009)	The Urban Green Spaces Taskforce in England	Mell (2010)	Benedict and McMahon (2002;2006)
Classification approach	Scale-based	Based on land-use	Based on land cover (vegetation)	Based on function
Typologies	Local, neighbourhood and village scale Town, city and district scale City-region, regional and national scale: Street trees, verges, and hedges; Green roofs and walls; Pocket parks; Private gardens; Urban plazas; Institutional open spaces; Ponds and streams; Small woodlands; Play areas; Local nature reserves; School grounds; Sports pitches; Swales, ditches; Allotments; Vacant and derelict land. Town, city, and district scale: Business settings: City/district parks; Urban canals; Urban commons; Forest parks; Country parks; Continuous waterfront; Municipal plazas; Lakes Major recreational spaces; Rivers and floodplains; Brownfield land; Community woodlands; (Former) mineral extraction sites Agricultural land; Landfill City-region, regional and national scale: Regional parks; Rivers and floodplains; Shoreline; Strategic and long-distance trails; Forests, woodlands, and community forests; Reservoirs Road and railway networks	Park and gardens: Urban parks; Country parks; Formal gardens (including designed landscapes); Private gardens. Provision for children and teenagers: Play areas; Skateboard parks; Outdoor basketball goals. Outdoor sports facilities (with natural or artificial surfaces): Tennis courts; Bowling greens; Sports pitches (including artificial surfaces); Golf courses; Athletics tracks; School playing fields; Other institutional playing fields; Other outdoor sports areas. Amenity green space: Residential; Business-related; Transport-related. Allotments, community gardens and urban farms: Allotments; Community gardens; City (urban) farms Cemeteries and churchyards: Churchyards; Cemeteries Natural and semi-natural urban greenspaces, including woodland or urban forestry: Woodland (coniferous, deciduous, mixed) and scrub; Grassland (e.g., down land, meadow); Heath or more; Wetlands (e.g., marsh, fen); Open and running water (like spring); Wastelands (including disturbed ground). Green corridors: River and canal banks; Road and rail corridors; Cycling routes within towns and cities; Pedestrian paths within towns and cities	Form: <i>Ecological element</i> e.g., connectivity; physical space; elements. <i>Economic</i> e.g., cost and design of the space. <i>Social & cultural</i> e.g. users of a space, aesthetics of a space, motivations. Function: <i>Ecological element</i> e.g., biodiversity and conservation. <i>Economic</i> e.g., industry, business, regeneration. <i>Social & cultural</i> e.g., educational, recreations, health. Context: <i>Ecological element</i> e.g., Biodiversity; Supporting networks; Ecological mobility. <i>Economic</i> e.g., costs of a space, economic development, sustainability <i>Social & cultural</i> e.g. Location, facilitations, motivations, perceptions.	Hubs: <i>Large parks and reserves</i> Natural reserves; national parks of conservation value or wildlife resorts. <i>Working lands</i> Privately owned farms: forests employed for production purposes. <i>Recreational parks and others natural areas</i> Smaller parks or natural areas providing important ecological and social values, such as habitats and a space for nature-based recreation. Links: <i>Landscape linkages</i> Large protected natural corridors <i>Conservation corridors</i> Rivers, stream floodplains and forested corridors. <i>Greenways and greenbelts</i> Protective corridors for resource conservation or to preserve native ecosystems and agricultural (working) lands. <i>Eco-belts</i> Buffer zone between urban and rural areas.

Table 3-1 continues.

Authors	Cvejić <i>et al.</i> (2015)	Ruppercht and Byrne (2014)	Davies <i>et al.</i> (2006)	Stiles (2006)
Classification approach	Scale, location within city and function.	Informal green spaces	Function-based	Function-based
Typologies	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, scrubland, 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	Street verges: Roadside verges, roundabouts, tree rings, informal trails, and footpaths. Lots: Vacant lots abandoned lots. Gap: Gap between walls or fences Railway: Rail tracks, verges, stations Brownfield: Landfill, post-use factory grounds, industrial park Waterside: Rivers, canals, water reservoir edges Structural: Walls, fences, roofs, buildings Microsite: Vegetation in cracks or holes Power line: Power line rights of way	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.

Source: Own construction based on Dunnett *et al.* (2002); Landscape Institute (2009); Benedict and McMahon (2006); Davies *et al.* (2006); Stiles (2009); Mell (2010); Scottish government (2011); Ruppercht and Byrne (2014); Cvejić *et al.* (2015); Koc *et al.* (2017).

The typologies developed by the authors included in **Table 3-1** are not all-encompassing as numerous other typologies have been developed in the literature (refer to Koc *et al.*, 2017:19-20 for a list of authors that reflects on GI typologies). Thus, underscoring the complexity and diversity in the GI (and green spaces) typology debate (Cilliers & Cilliers, 2016:11).

3.3.2 A South African perspective towards GI and the classification of GI elements

When it comes to the topic of GI, Cilliers and Cilliers (2016:22) claim South African planning and decision-making presents a unique perception of “green” and GI planning. In South Africa, as in several other developing countries, ecological issues often fail to compete against problems of lacking infrastructure such as roads, clinics, and housing shortages (Cilliers, 2019a:455). In many instances, the lack of prioritisation given to ecological spaces or planning for GI elements in the South African context, is ascribed to the fact that these spaces are regarded as “luxury” or a “visual attribute” and not yet as a necessity (Schäffler & Swilling, 2013:247; Cilliers & Cilliers, 2016:22). Pasquini and Enqvist (2019:9) claims this perspective could be because of a lack of ecological literacy. Also, Huston (2018:135) indicated that the current use of GI in South African practice is extremely limited predominantly because of such misconceptions and inadequate GI education. Consequently, according to Pasquini and Enqvist (2019:10), South African urban planners and decision-makers are on a “path dependence” with difficulties to break away from specific past development strategies (traditional grey infrastructure) in favour of the incorporation of green resources for GI. On the other hand, the successful implementation of GI in South Africa is influenced by the lack of “know-how” and knowledge pertaining GI (Cilliers, 2019a:445).

It is Cilliers and Cilliers (2016:11) that emphasise the complexity and diversity of the GI typology debate within a South African context. For instance, The City of Tshwane refers to green spaces as “ecologically sensitive open space” (City of Tshwane, 2005:10). Another study in a South African context defines green spaces as a “network of all natural and semi-natural ecological systems in urban areas” (Cilliers *et al.*, 2013:683) including for instance urban forests and grassland (Dusza *et al.*, 2017:2358). The latter are also considered by Shackleton and Blair (2013:104) as ecologically green spaces constituted by the remnants of patches of natural landscapes and indigenous vegetation providing habitats and other ecosystem services. GI are also classified in a South African context as “public green spaces” including any formal or informal green areas, for instance school grounds open to the public after school hours, sport fields and designated parks (Shackleton & Blair, 2013:104). Adegun (2018a:330) mentioned parks, as well as street trees, domestic and community gardens, and wetlands as elements of GI. Some South African articles have differing considerations regarding GI. In 1989 the city of Durban was the first city in South Africa to adopt a Metropolitan Open Space System, referred to as the Durban Metropolitan Open Space System (The D'MOSS) (Boon *et al.*, 2016:2). The D'MOSS is described

as an open space system developed to protect valuable ecosystems through the management and protection of open spaces and their biodiversity within the Durban Metropolitan area (Sutherland *et al.*, 2018:338). Based upon the conception of the D'MOSS, other GI concepts such as an “*ecologically functional bio-infrastructure network*” was considered in South African literature (Roberts *et al.*, 2012:167). Some other authors refer to Green Infrastructure (GI) as the nature-based equivalent of “*ecological infrastructure*” (EI) (Cumming *et al.*, 2014; Bobbins & Culwick, 2015:5). Da Silva and Wheeler (2017:32) refer to EI as “ecosystems as infrastructure”. Within a South African context, EI includes the conservation, restoration, and protection of ecosystems as nature-based equivalent of infrastructure (Sigwela *et al.*, 2017:275) including mountains, rivers, coastal areas, wetlands, and hubs and links of natural habitats (SANBI, 2013:1). While Cumming *et al.* (2017:260) acknowledge EI as a synonym of GI, however Matthews *et al.* (2015:155) disagrees. The definition provided by Matthews *et al.* (2015:155) distinguishes GI from EI, emphasising that EI tends to focus more predominately on natural ecosystems (e.g., mountains, rivers, coastal areas, wetlands, and hubs and links of natural habitats) (SANBI, 2013:1), whilst GI is restricted to “biological resources” within *urban areas*.

Cilliers and Cilliers (2016:10) claim that planners are unaware of the types of GI elements for possible implementation seeing that attempts to develop a comprehensive GI typology is scarce within the South African context. Or in other words, South African urban planning practice lacks a comprehensive typology of GI elements to inform urban planners on GI elements possible for implementation. A discussion of certain attempts to determine and classify different GI typologies in the South African context follows.

3.3.2.1 *GI typologies in South Africa*

The State of Green Infrastructure in the Gauteng City-Region (GCR) report developed by Schäffler *et al.* (2013), framed GI as including both natural and man-made ecological features that provide services to society. Thus, Schäffler *et al.* (2013:29) propose two typologies, namely: man-made green spaces and ecological green spaces (refer to **Table 3-2**). The man-made green spaces include green spaces predominantly artificially created (Cilliers & Cilliers, 2016:13). On the other hand, ecological green space classified with visible natural surfaces and ecological functions (Cilliers & Cilliers, 2016:13).

As indicated in **Table 3-2** the Durban Metropolitan Open Spaces system (D'MOSS) classified open spaces based on function. The open spaces that comprise the system include all open spaces of which the primary function is ecological (Rajak, 2015:16). These open spaces, whether hard or soft spaces, are divided into five key categories, namely natural, recreational, surfaced, productive and utility open spaces (Rajak, 2015:16) (refer to **Table 3-2**).

Furthermore, the City of Tshwane developed open space typologies to conceptualise the spatial configuration of the open space network within the City of Tshwane (City of Tshwane, 2005:23). Their typology identified and developed five open space categories. **Table 3-2** illustrates that the typology of open space suggested by the City of Tshwane each comprises of a “node” and “linear way” akin to Benedict and McMahon’s (2006:7) “hub” and a “link” classification (c.f. section 3.4.1).

Another typology discovered in the South African context was developed by the Guidelines for Human Settlement Planning and Design, also known as the “Red Book” (CSIR, 2019). The Red book considers open spaces as soft (green) or hard (paved) open spaces. As seen in **Table 3-2**, these spaces are subdivided into different categories of spaces based on their functions (CSIR, 2019: G.17). The Red Book also refers to some “grey-green design” elements with regards to storm water systems. These elements are referred to as “Sustainable Drainage Systems” aiming to improve water quality by managing storm water runoff through natural interventions (green spaces) rather than traditional grey infrastructure such as pipes and culverts (CSIR, 2019: L.9).

Table 3-2 captures the different typologies as proposed by South African authors discussed above (City of Tshwane, 2005; Schäffler *et al.*, 2013; CSIR, 2019). The table also includes the different categories of green or open spaces (depending on the term used by authors), as well as the examples of spaces proposed concerning the different categories.

Table 3-2: Green infrastructure typologies based on South African perspectives

Authors	Schäffler <i>et al.</i> (2013)	DMOSS	City of Tshwane (2005)	CSIR (2019)
Classification approaches	Land cover	Function-based	Form	Function-based
Typologies	Man-made green spaces: School grounds; Sport and recreational; Golf courses; Cultivated, commercial agricultural (irrigated); Cultivated, commercial agriculture (dryland/rain fed) Natural green spaces: Rock and soil, or open space with little or no vegetation; wetlands, natural grassland; Thicket; bushland and bush clumps; Forest (indigenous); Trees (non-natural) Planted and natural grassland; Degraded natural vegetation.	Natural Open Space: Terrestrial Ecosystems: Forests, Grasslands; Riverine Ecosystems: Rivers, wetlands, Floodplains; Coastal Ecosystems (Sand Dunes); Marine Ecosystems (Estuaries, Bays) Potential Ecosystems (Degraded areas with the potential to rehabilitate). Recreational Open Spaces: Sports Fields, Parks, Nature Reserves Surfaced Open Spaces: Public Squares; Sidewalks; Markets Productive Open Spaces: Agriculture; Dams; Grazing Utility Open Spaces: Road Reserves; Rail reserves; Utility Servitudes	Green networks: Ecological nodes such as important habitats for fauna and flora, local biomes, High Ecological Sensitivity sites. Green ways (e.g., ridge system) Blue networks: Dam and Wetland as blue nodes and water courses as blue ways. Brown networks: Local parks as brown nodes, for example, multipurpose Sports Facility, Sports Stadium, Recreational Park, and activity streets as brown ways. Grey networks: Grey notes including Landfill Site, Cemetery, Mine, Quarry, and parking Lot. Grey ways as railway line Red networks: Culture Historical and recreational futures as red notes and boulevards as red ways.	Soft open space surfaces: Nature reserves Parks Play spaces. Sites for urban agriculture Sports field Hard open spaces: Squares Streets Public transport stops. Parking lots Sustainable Drainage Systems Rainwater harvesting Green roofs Permeable pavements Soakaways Swales Infiltration trenches Bio-retention areas Detention ponds Constructed wetlands

Source: Own construction based on City of Tshwane (2005); Schäffler *et al.* (2013); CSIR (2019).

Cilliers (2019a:455) mentioned the lack of contextualisation of GI within the South African planning context. The following section reflects further on the South African context, with the aim of identifying gaps and considerations of green spaces that still requires to be included in a South African GI typology.

3.3.2.2 *Gaps and required considerations for a comprehensive South African Green Infrastructure typology*

Lovell and Taylor (2013:1447) propose that the concept of GI should be expanded. In particular, by including those green spaces that are privately owned, for example private home gardens (Landscape Institute, 2009; Lubbe *et al.*, 2011; Cameron *et al.*, 2012:129; Cilliers *et al.*, 2013:670; Cilliers *et al.*, 2018). Private home gardens are considered as an important GI element on local level, however according to Gómez-Baggethun and Barton (2013:240) these green spaces are not directly subjected to *public* urban planning and therefore do not receive as much attention as public GI elements (Shackleton *et al.*, 2018; Cvejić *et al.*, 2015:12). In the South African context, the study of Shackleton *et al.* (2018) discovered that the most prominent GI element in small and medium-sized towns are gardens predominantly under private tenure, however these home gardens are often excluded as part of the broader GI. Authors such as Cilliers *et al.* (2018) and Lindley *et al.* (2018) emphasise the need to shed lighter on privately owned gardens as potential GI elements for enhanced multi-functionality (Iojă *et al.*, 2014:704), provision of important ESS (Lovell & Taylor, 2013:1447), supporting biodiversity (Cilliers *et al.*, 2013:670) and overall contributions to quality of life in urban areas (de la Barrera *et al.*, 2016:212).

Despite the necessity of including private home gardens as important element of GI, Shackleton, and Blair (2014:104) urge the fact that some urban residents, especially those living in low income and high-density suburbs, have limited access to gardens attached to their dwellings. For residents in such communities' public green spaces are essential to sustain well-being and provide environmental benefits (Lategan & Cilliers, 2014:436; Lindley *et al.*, 2018:337). In the event of this, Shirleyana and Sari (2013) recognises the potential of “pocket parks” as quality public green spaces in highly dense settlements.

Further in the light of South African public GI, an often-neglected area in South African green space planning studies is the inclusion of botanical gardens as part of the broader public green space typology (Ward *et al.*, 2010:55). South Africa boasts nine national botanical gardens that are described by the South African National Biodiversity Institute (SANBI, 2006) as “*unique*” public green spaces as they are hosts of high biodiversity, as well as providers of recreational and educational services for the public (SANBI, 2006:28).

A further unique consideration regarding GI elements in a South African context is that many African cities still retain significant remnants of existing nature or fragments of natural habitats (Lindley *et al.*, 2018:338). In particular, two cities in South Africa, namely Cape Town and Durban, are described as “biodiversity hotspots” of international importance (Lindley *et al.*, 2018:338), while the Gauteng-province is situated wholly within two of the nine national biodiversity priority areas of South Africa (Pfab *et al.*, 2017: a2182). Roy *et al.* (2018) recognised that most of the green elements found in informal settlements are not formally planned, however are natural remnant vegetation. Although, many of these natural remnants in urban areas are undervalued (Holmes *et al.*, 2012:28) and often degraded (Lindley *et al.*, 2018:338), Pfab *et al.* (2017: a2182) emphasises that many South African urban environments fundamentally depend on these natural remnants, providing biodiversity and necessary ESs contributing to sustainable and healthy environments. As detailed in **Table 3-2**, green space typologies in a South African context often recognise these natural remnants as natural wetlands, natural vegetation (Schäffler *et al.*, 2013) or local biomes (City of Tshwane, 2005) rivers, wetlands, and forests (Bobbins & Culwick, 2015). Chishaleshale *et al.* (2015:817) especially emphasise attention to proactively planning for forests and urban trees as part of forests.

Some SA cities have systematic conservation plans that identify critical biodiversity areas (CBA's) and other important natural green spaces outside nature reserves (McLean *et al.*, 2016; Pfab *et al.*, 2017). Systematic conservation plans are a standard approach in South Africa for biodiversity planning identifying priority biodiversity areas within a landscape necessary for conservation of natural areas (SANBI, 2020b). Although, systematic conservation plans are not directly recognised as part of GI planning, they focus on natural areas (vegetation) and are widely used in larger South African cities. Systematic conservation plans could consider elements, for instance existing protected areas, species-specific data, and ecosystem types, ecological processes, and conditions, as well as elements of land-uses (Botts *et al.*, 2019:1240). The elements included in systematic conservation plans are divided into Critical Biodiversity Area's (CBA's) and Ecological Support Area's (ESA's) and other classes. CBA's refer to those irreplaceable and important areas including Threatened, Near-Treated, rare and less extensive fauna and flora that require protection, while the ESA's are considered as other areas not included as CBA's but provide important ecological processes, such as wetlands and rivers (Pfab *et al.*, 2017:10). Systematic conservation plans explicitly inform spatial decision-making that seeks to find optimal solutions to accommodate both people and nature in increasing limited urban space (Botts *et al.*, 2019:1263). CBA's and ESA's are also mentioned in the “Red Book” and are emphasised to receive special consideration when planning and designing urban green spaces (CSIR, 2019: G.13). Both O'Farrell *et al.* (2012:27) and Lindley *et al.* (2018:338) also urge more consideration and enhanced planning for these parcels of “existing nature” in South African urban areas (Roberts,

2013:308). According to McDonnell *et al.* (2009:383) the planning for and preservation of remnant nature is part of the ecological approach to quality green space provision.

Roy *et al.* (2018) furthermore calls for “*creative urban planning*” by including those less obvious spaces or informal “non-traditional” green spaces (IGS) (Rupprecht *et al.*, 2015), for instance, vacant lands, brownfields, roadside and roundabout vegetation (Anderson *et al.*, 2016:446; Rupprecht, 2017:883; Roy *et al.*, 2018). Even though these IGS are an integral part of everyday urban areas and dwellers' daily lives, they are often not valued and are under-maintained (Rupprecht, 2017:883). Brownfield areas, for instance old industrial areas or wastelands are commonly associated as ugly, useless, unpleasant, or unsafe (Lyytimäki *et al.*, 2008:168). In line with this, Kim (2016:486) noticed that vacant land is also often associated with negative connotations as being dangerous or abandoned. However, Kim (2016) suggests the “re-imagining” of these spaces as part of GI and as valuable spaces to generate potential ecosystem services contributing to overall urban health and well-being.

Lindley *et al.* (2018:337) notice the necessity for including a variety of urban agricultural approaches in South African GI planning. Urban agriculture could be described as the cultivation of plants for food and the production of livestock within urban areas (RUAF, 2009; Lin *et al.*, 2017:115). Typically, urban agricultural GI elements would include for example sub-urban farms, on rooftops, in residential backyards, home gardens, through urban horticulture or employing communal gardens (Gómez-Baggethun *et al.* 2013; Adegun, 2018b:348). Schäffler and Swilling (2013:247) and Cilliers *et al.* (2018:298) especially highlight the importance of considering of all gardens as important part of GI elements, including horticulture and communal gardens (Cvejić *et al.*, 2015:12; Anderson *et al.*, 2016:446; de la Barrera *et al.*, 2016:212). These gardens are important for informal greening practices in society, for instance through gardening clubs and horticultural supply chains (Schäffler & Swilling, 2013:247). The involvement of different stakeholders of society in these informal greening practices creates the opportunity of co-production of knowledge and a social network between communities (Cilliers *et al.*, 2018:303).

Du Toit *et al.* (2018) stress the need for Sub-Saharan Africa, including South Africa, to consider the use of green resources in their broader traditional grey infrastructure development. As such, “grey-green design” solutions, for instance rain gardens, bioswales, constructed wetlands and green walls, should also be a part of green spaces typology within a South African context. These green spaces also form part of water sensitive urban design and sustainable urban drainage systems as mentioned in the red book (CSIR, 2019) (c.f. **Table 3-2**).

3.4 Constructing a comprehensive typology inventory of Green Infrastructure elements for South African urban planning practice

According to Dunnett *et al.* (2002:9) the formulation of a green space typology will to a great extent depend on the practical employment thereof. This dissertation attempts to develop an inventory of green infrastructure (GI) elements for the South African urban planning practice that are in line with Cilliers's (2015:83) suggestion to create a typology that includes different green space categories possible for implementation in urban planning practice. The section attempts to fulfil the identified gaps of GI elements of a South African GI typology by considering opportunities of GI elements mentioned by South African and other (international) literature.

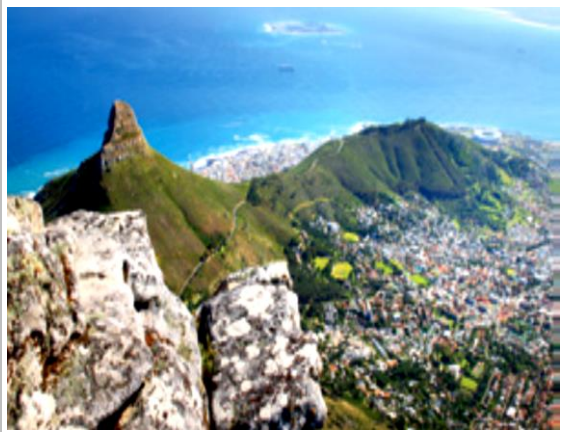
As a result, the following table (**Table 3-3**) captures a comprehensive synthesis of a variety of GI elements and their description. Some of the GI elements included in **Table 3-3** were identified in the previously discussed South African GI typologies (**Table 3-2**), while other GI elements were gathered from the international GI typologies presented (**Table 3-1**).

Table 3-3: A typology inventory of Green Infrastructure elements composed for South African urban planning practice.

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
GREY-GREEN DESIGNED ELEMENTS		
Green wall	A form of a vertical (e.g., facades, walls, blind walls, partition walls) vegetated surface (Manso & Castro-Gomes, 2015:863; Collins <i>et al.</i> , 2017:114).	 Source: Francis <i>et al.</i> (2014).
Green roof (or garden roof)	A vegetated landscape installed on a roof surface (Francis <i>et al.</i>, 2014:4). Uses soil and plants in the place of traditional roof material. In a South Africa context also referred to as an “eco-roof” or “garden roof”.	 Source: Booysen (2014).

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
Sustainable Urban Drainage Systems	Constructed wetlands	Human-made wetlands replicating the occurring natural processes (e.g., water purification and waste-water treatment) of natural wetlands. (Stefanakis, 2019: 6981). Constructed wetlands are similar to natural wetlands, composed of plants, substrate, and microorganisms (Licata <i>et al.</i>, 2019:2).  Source: Licata <i>et al.</i> (2019).
	Bioswales	Bio or vegetated swales (also known as storm water runoff conveyance systems) are an engineered linear shallow trench of multi-layered vegetation (including trees, shrubs, wildflowers, and grass) that capture large amounts of surface storm water runoff and remove pollutant before storm water infiltrate back into the ground (Dinić-Branković <i>et al.</i>, 2018: 348). Usually employed alongside streets and parking areas (Green Infrastructure Ontario Coalition, 2017:46).  Source: UNISA (2017).
	Rain garden	Rain gardens are typically lowered landscaped garden beds collecting rainwater from rooftops, streets, parking areas and sideways and storing it for a period of time in the rain garden basin, in order for the water to slowly infiltrate back into the soil (Dussailant <i>et al.</i>, 2004:219). Rain gardens are smaller systems than swales and do not require intensive engineering practices (Green Infrastructure Ontario Coalition, 2017:46).  Source: EPA (2007).

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
URBAN AGRICULTURE		
Community garden	A public shared or undeveloped private land, utilised to produce agricultural goods by a group of individuals within a community, primarily for their own consumption (Drescher <i>et al.</i> , 2006:317).	 Source: Ed Ritger for San-Francisco Public Press (2010).
Vertical Farming	Similar to a green wall, vertical farming refers to the practice of cultivating crops in vertically layers or the integration of crops in a vertical structure (e.g., a building) (Royston & Pavithra, 2018:500).	 Source: Design Indaba (2013).
Rooftop Farming	Similar to a green roof, however rooftop farming refers to the agricultural practice or the cultivation of fruit and vegetables on a roof surface (Walters & Stoelzle Midden, 2018:168).	 Source: Cuizine (2015).

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
Horticulture	The term “horti” is the Latin word “hortus” meaning garden. Public land devoted to agriculture purpose for growing plants fruits, vegetables, and flowers, spices that are used by people for medicinal purposes, or food and for aesthetic gratification (Cvejić <i>et al.</i>, 2015:15). Sometimes includes organic farming (growing crops without synthetic agricultural chemicals) (Western Australian Agriculture Authority, 2014: 21).	 Source: Horticulture (2020).
URBAN NATURAL REMNANTS		
Urban forest	An area of natural or planted tree vegetation in and around urban areas includes urban woodlands, natural forests and plantations or individual trees such as trees in parks, cemeteries and in other open spaces (Konijnendijk & Randrup, 2004:472). Includes smaller scale single-stemmed tree linings planted and growing along right of-way spaces, including streets, or verges, or pathways (Steed & Fischer, 2007:1; McPherson <i>et al.</i>, 2016:104)	 Source: Hello Joburg (2019).
Existing or remnant natural areas	Existing natural remnants, for example natural and restored native ecosystems (Benedict & McMahon, 2006:7), and other natural fragments representing naturally occurring or rehabilitated indigenous vegetation cover of local biomes (Shanahan <i>et al.</i>, 2015:155) that could be included in urban nature reserves. Some SA cities have systematic conservation plans that identify critical biodiversity areas (CBA's) and other important natural green spaces outside nature reserves (McLean <i>et al.</i>, 2016; Pfab <i>et al.</i>, 2017). Depending on location of the city these remnants can form part of one of the following South African biomes includes: Fynbos, Succulent Karoo, Desert, Nama-Karoo, Grassland, Savanna, Albany Thicket, Indian Ocean Coastal Belt, Forests (Rutherford <i>et al.</i>, 2006:33) which are further divided into bioregions and vegetation types (Mucina & Rutherford, 2006).	 Source: SANParks (2020).

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
Natural wetlands and ponds	Waterbodies formed by means of sediment deposits on water banks with either permanently or periodically water and a variety of flora and fauna characteristic (Cengiz, 2013:552; Cvejić <i>et al.</i> , 2015:27). The South African Department of Environmental Affairs (DEA) claims wetlands are found in and around cities and suburbs that are often placed under nature reserves for protection. Wetlands can be freshwater or coastal systems (Mucina & Rutherford, 2006).	 Source: City of Cape Town (2010).
Urban river or stream	Linear running water resource flowing in urban areas with either artificial or natural banks and characterised with vegetation and other sediments (Yue, 2012:1).	 Source: Davie for Heritage Portal (2018)
PUBLIC GREEN SPACE		
Urban parks	Generally, a publicly accessible, artificially created green space that includes features of vegetation, trees, lawns, flowerbeds, sometimes water features, as well as other design features such as walking paths, play areas, range of activities, seating, picnic tables, and bathrooms (McCormack <i>et al.</i>, 2010:716) Urban parks are predominantly large but could also include smaller sized parks – “pocket park” (Konijnendijk <i>et al.</i>, 2013:2).	 Source: Sergio Grazia for ensia (2018).

	DESCRIPTION OF THE GI ELEMENT	EXAMPLE OF THE GI ELEMENT
Botanical garden	Institutions holding public space for the conservation of biodiversity including a large variety of plant species for the purpose of research, education, display (ornamental) and recreational activities (Krishnan & Novy, 2016:023). South Africa boasts the following national botanical gardens: Kirstenbosch; Hantam; Water Sisulu; Harold Porter; Free State; Pretoria; Karoo Desert; KwaZulu-Natal; Lowveld; Zoo; Kwelera; Thohoyandou; Mokopane Biodiversity Conservation Centre (SANBI, 2015). The Kirstenbosch National Botanical garden is considering a flagship botanical garden in SA and one of the top 10 botanical gardens in the world (Van Wilgen, 2013:1).	 Source: SANBI (2020a).
Golf course	A lawn that consists of both cultural (a social gathering spaces) and ecological (support wild fauna and flora) phenomena (Eriksson <i>et al.</i>, 2015:478).	 Source: Eriksson <i>et al.</i> (2015).
Other green sport facility (sports fields)	Cultivated and fertilised grass turf tolerant for sport activities (e.g., soccer field, hockey fields etc.) (Cvejić <i>et al.</i>, 2015:15).	 Source: Cvejić <i>et al.</i> (2015)

	DESCRIPTION OF THE GI ELEMENT	EXAMPLE OF THE GI ELEMENT
Child-friendly space	A space intentionally planned and developed for the purpose and needs of children to enjoy the natural environment and contribute to their development (often consider as a component of urban parks) (Cilliers & Goosen, 2016:794).	 Source: Johnson (2013).
School grounds and campus green spaces	School grounds are important small-scale element of urban green infrastructure providing multiple uses, such as educational, recreational, and inspirational benefits, as well as could include green resources for instance lawns for sport fields, gardens, trees, and other flora (Iojă et al., 2014:705)	 Source: Archello (2020).
Health clinic garden	Gardens established around health facilities, providing them with a green space to cultivate fruit, vegetables, and medicinal plants for the patient of the health facility, as well as, for the surrounding community (Cornelius, 2016:25).	 Source: Project HOPE UK (2019).
Cemeteries or burial grounds	A large, landscaped park constructed based on religious and cultural practices, that facility burials and memorialising individuals. Cemeteries extend beyond a place of burial but could serve as a historical space, such as war cemeteries (Rugg, 2000:263).	 Source: City of Tshwane (2015).

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
PRIVATE GREEN SPACES		
Private home gardens	Predominantly a small privately owned space adjacent to domestic dwellings for the purpose of cultivating a variety of flora species (mainly for ornamental purposes) and plants for food, natural healing remedies and construction material (Lubbe <i>et al.</i>, 2011:360; Cameron <i>et al.</i>, 2012:129).	 Source: Adegun (2018a).
INFORMAL GREEN SPACES		
Riverbank greenery	Publically accessed (foot or bike paths) vegetated spaces on the sideways of rivers, streams, and canals (Rupprecht & Byrne, 2014:600).	 Source: Own construction (2020).
Roadside or railway greenery	Intersections or strips of land that border roads and railway embankments, could range from a few centimetres to a few metres of vegetation, habitats, forest, or artificial horticultural plants (gardens) (Phillips <i>et al.</i>, 2020:488).	 Source: Own construction (2020).

DESCRIPTION OF THE GI ELEMENT		EXAMPLE OF THE GI ELEMENT
Vacant land	A parcel of land divided into previously developed land or previously undeveloped land. Previously developed land often has existing building structures, while previously undeveloped land is left over from earlier development or are unbuilt due to steep slopes or flood hazard (Pagano & Bowman, 2004:15). The land often contains vegetation such as natural forests and a higher species diversity relative to other land uses (Kim, 2016:486).	 Source: Kim <i>et al.</i> (2018).

Source: Own construction based on various sources (2020).

The strength of **Table 3-3** is that it includes a comprehensive inventory of GI elements organised and evidence-based to inform South African urban planners on types of GI elements (in addition to those indicated in **Table 3-2**) possible for implementation. These GI elements are part of the holistic approach to deliver ESs via spatial planning (Lennon & Scott, 2014a). According to both Boulton *et al.* (2018) and Pasquini and Enqvist (2019:20) urban planners, responsible for green space provision are required to comprehend the broad spectrum of ESs these GI elements generate for both communities, authorities, and the environment (Cilliers, 2019a:455).

However, according to several researchers, urban planners and other city-officials have an inadequate understanding and recognition of the ESs and benefits derived from GI elements (De Groot *et al.*, 2010:266; Mascarenhas *et al.*, 2014:1290; Pasquini & Enqvist, 2019:20). De Groot *et al.* (2010:266) as well as Mascarenhas *et al.* (2014:1290) claim urban planners lack comprehension of the terminology related to ESs. Furthermore, Mascarenhas *et al.* (2014: 290) argues that urban planners are unsure and unfamiliar with examples of ESs and what the benefits of ESs are in urban areas. It is suggested that research regarding the concept of ESs is required in order to assure urban planners regarding the usefulness of the GI concept and further on how GI element could contribute to planning for ESs (Hansen, 2018:28; Hansen *et al.*, 2019:99). The comprehension and integration of ESs in urban planning could result in the opportunity for human environments to exist in balance with the wider ecological system (Marcotullio, & Boyle, 2003:6) and also to guide urban planning with an ecosystem-based focus as a future path of urban planning practices (Geneletti *et al.*, 2020:67).

3.5 Conclusion

In this chapter of the literature investigation, the aim was to outline typologies of GI according to various international and local authors (South African) in order to compose a comprehensive inventory of GI elements for South African urban planning practice.

An unanticipated finding was that classification of GI elements into a typology had a strong bias towards international literature and considerable progress has been made with developing a variety of international GI typologies. These typologies included a comprehensive range of GI elements, ranging from public and private green spaces, natural remnants (both blue and green spaces), as well as green-grey design elements. An observed difference between international and South African GI typologies was significant in this chapter. The latter typologies identified public green spaces (see **Table 3-2**) but had a stronger focus on the natural remnants (both blue and green spaces). These findings highlight the importance of safeguarding these natural remnant green spaces, especially in those South African cities that are biodiversity rich. A gap identified in the SA GI typologies were identified regarding private green spaces, as well as a diverse variety of urban agricultural spaces. Furthermore, attempts on developing SA typologies often excluded grey-green design GI elements.

These findings were also reported by Cilliers and Cilliers (2016) that stated in general South African authors exclude comprehensive GI elements in their typologies such as those proposed by international authors (**Table 3-1**), and there is thus still significant progress to be made in this regard. This result may be explained by the fact that South African urban planners lack broad knowledge pertaining different GI elements. International typologies offered the opportunity to fill the gaps of the South African typology and was presented in a comprehensive inventory in **Table 3-3**. According to the literature more research on ESs generated by these GI elements could help enhance the importance of a GI typology to urban planners. However, a neglected area in the urban planning field is the clarification of ESs to urban planners there is, therefore a definite need for conceptualise ESs in an urban planning context and is considered in the following chapter.

CHAPTER 4 – CONSIDERING THE ECOSYSTEM SERVICES CONCEPT FOR AN URBAN PLANNING AUDIENCE

4.1 The structure of Chapter 4

Figure 4-1 illustrates the structure for the following chapter (Chapter 4).

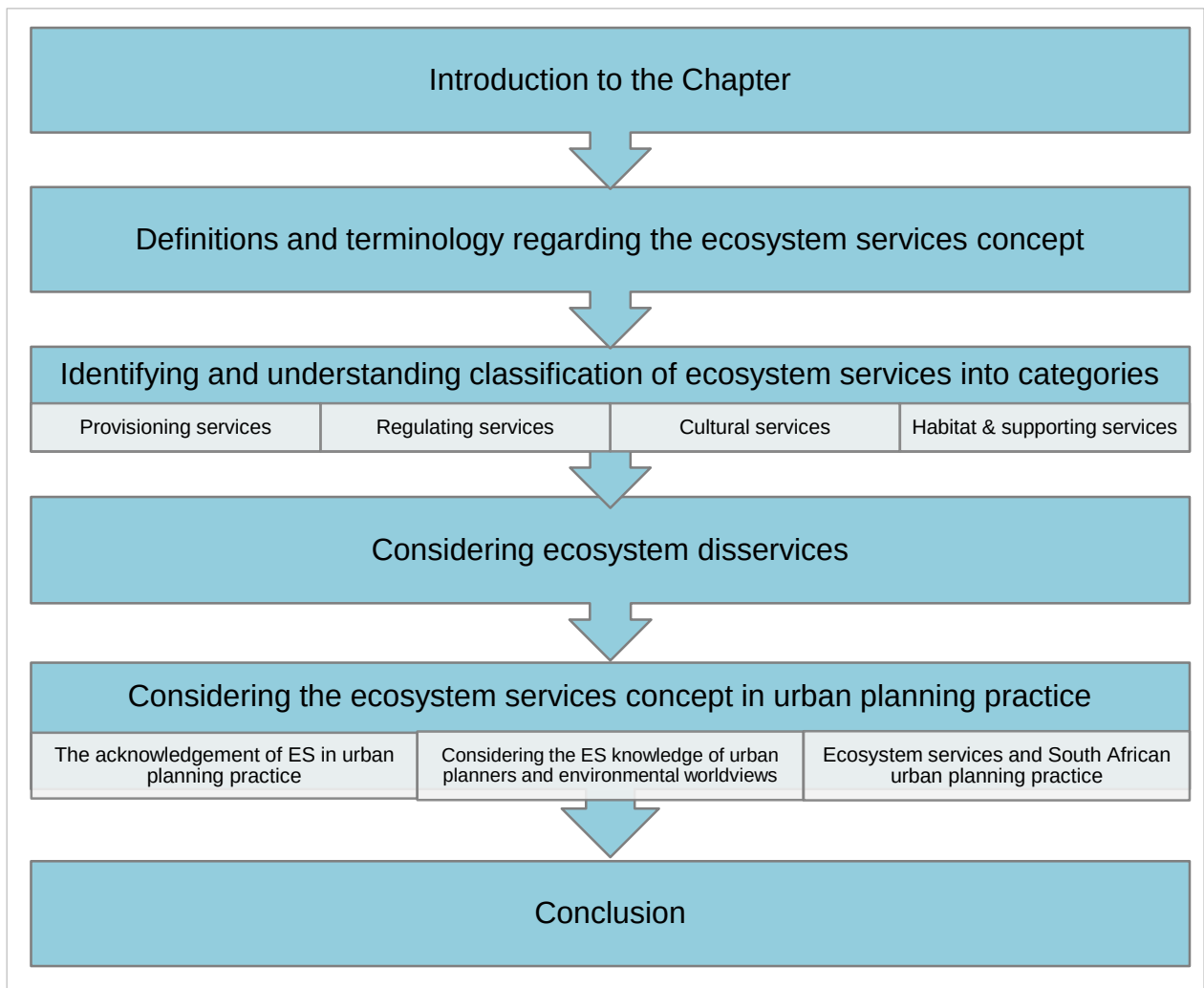


Figure 4-1: The structure of Chapter 4.

Source: Own construction (2020).

4.2 Introduction to the Chapter

The ecosystem services concept is used increasingly as a way to link nature to human quality of life (health and well-being) in urban areas (Escobedo *et al.*, 2011:2079). The ecosystem services (from hereafter referred to as ESs) emphasises the fact that the “natural” components of urban ecosystems provide a range of “free” benefits to environmental quality and urban populations (Colding, 2011:229; Steiner, 2014:1). When referring to the ESs provided by the components of

urban ecosystems, several scholars refer to green infrastructure (GI) elements and the large variety of ESs generated from these elements as an emerging research theme (Schäffler *et al.*, 2013:180; Ahern *et al.*, 2014:255; Andersson *et al.*, 2016:445; Hansen & Pauleit, 2014; Di Marino *et al.*, 2019:644). The concept of ESs however mainly remains unfamiliar to urban planners regarding terminologies, examples, and benefits (Di Marino *et al.*, 2019:644; La Rosa, 2019:1). In the study of Du Toit *et al.* (2018:250) on sub-Saharan African countries, it was recognised that South Africa is the forerunner with research on the ESs concept, however the linkage between the ESs concepts to South African urban planning practice is still slow to emerge and there is significant scope for progress to be made in this regard. Both Niemelä *et al.* (2010:3238) and Di Marino *et al.* (2019:644) stress that the ESs concept in planning is not straightforward and tends to be abstract and complex for urban planning practice. Albert *et al.* (2014:1303), as well as Kremer *et al.* (2016:29), suggest that urban planning practice requires “easy-to-understand and practical information” regarding ESs, including the benefits these services hold for human well-being and the urban ecosystems (GI) that generate them. Along the same lines, Sitas *et al.* (2014:3813) claim that researchers are required to communicate and translate their research in ways that are understandable for their intended audience. Ultimately, this chapter captures the terminologies, significance, and benefits of ESs and describes and conveys them to an urban planning audience who may not be familiar with the concept and its potential.

4.3 Definitions and terminologies regarding the ecosystem services concept

According to Grunewald and Bastian (2015:1) the ESs concept is not new. The concept dates back to the 1970's (Osmond & Pelleri, 2017:34) when the term “environmental services” was used (Haines-Young & Potschin, 2010:111) to describe the free services natural ecosystems provide to humankind (Grunewald & Bastian, 2015:1). Bolund and Hunhammer (1999: 293-299) were the first to list ESs specifically provided from *urban* ecosystems, such as ESs derived from treed sidewalks, lawns, and parks, urban forests, cultivated land, wetlands, lakes, oceans, and streams. Thereafter the concept of ESs gradually gained attention (Gómez-Baggethun & Barton, 2013:240). The concept was especially mainstreamed by the Millennium Ecosystem Assessment (MA, 2005) which recognised the impact ESs has on human health and well-being (De Groot *et al.*, 2010:266). Subsequent work was done by the international initiative, The Economic of Ecosystem and Biodiversity study (TEEB, 2010).

Several definitions regarding ESs are applied by different disciplines (Cilliers *et al.*, 2013:682). A clear and uncontroversial, universally agreed upon definition has not yet been developed (Fisher *et al.*, 2009:643; Grunewald & Bastian, 2015:11). According to Gómez-Baggethun and Barton (2013:236) different ecosystems provide different types of ESs, and a suitable ESs definition requires a general classification to the specific type of ecosystem being studied. **Table 4-1**

provides definitions developed by different authors regarding ESs provided by *urban* ecosystems. As previously discussed in Chapter 2, when referring to “urban ecosystems” or “ecosystems in urban areas” the dissertation specifically focuses on the GI elements, including all natural, semi-natural and engineered or artificially made green spaces as discussed in Chapter 3 (**Table 3-3**).

Table 4-1: Definitions of urban ecosystem services

AUTHOR	DEFINITION
Costanza <i>et al.</i> (1997)	Ecosystem goods (e.g., food) and services (e.g., waste assimilation) human populations derive from urban ecosystem.
Eamus <i>et al.</i> (2005)	Ecosystem services are provided by or are attributes of ecosystems that benefit humans.
MEA (2005)	Ecosystem services are the benefits humans obtain from ecosystems including all benefits (ecosystem goods and ecosystem services).
Le Maitre <i>et al.</i> (2007)	The ecosystem functions that deliver the services as well as people who benefit from them.
Wallace (2007)	The values humans place on ecosystems and evaluating benefits derived from natural resources.
TEEB (2010)	The range of benefits humans derive from healthy natural environments
Escobedo <i>et al.</i> (2011)	The components of ecosystems that are directly enjoyed, consumed, or used to produce specific, measurable human benefits.
Secretariat of the Convention on Biological Diversity (2012)	Ecosystem services are the direct and indirect contributions of ecosystems to human well-being.
O’Farrell <i>et al.</i> (2012)	Ecosystem services represent the relevance and value of biodiversity to society
Swaffield and McWilliam (2013)	The benefits received by humans from sensory experiences of ecosystems, namely through sight, hearing, taste, smell, and touch
Osmond & Pelleri (2017)	The aspects of ecosystems to sustain or enhance human or nonhuman life.

Source: Own construction based on various sources (2020).

According to De Groot *et al.* (2002:394) and Grunewald and Bastian (2015:11) when it comes to the topic of ESs, a distinction between ecosystem “*function*” and ecosystem “*service*” is still an

on-going debate in research. Some authors consider ecosystem *services* as the services generated from ecosystem *functions* which are underpinned by habitat, biophysical structures, or the processes of an ecosystem, namely the flows of energy, materials, and species (Tzoulas *et al.*, 2007:171; Haines-Young & Potschin, 2010:111; Grunewald & Bastian, 2015:11). Therefore, ecosystem functions include biotic and abiotic processes, within and between ecosystems delivering functions such as air filtering, temperature regulation, and water storage, filtration, and drainage (Williams *et al.*, 2009:569). Hansen and Pauleit (2014:518) claim that while “functions” and “services” seem to be disconnected terms, functions have the same meaning as services, however, functions present *indirect* benefits to humans, while services are considered to be *directly* consumed or experienced by “human beneficiaries” (Haines-Young & Potschin, 2010:111; Hansen & Pauleit, 2014:518). The direct benefits from ecosystems are considered as the “goods” that humans directly utilise from ecosystems (Gómez-Baggethun & Barton, 2013:240) that directly impact human health and well-being (Fisher & Turner, 2008:1167). While the indirect benefits include ecological services (or ecosystem functions) that are not directly consumed by humans, however, these services are necessary to sustain the ecosystems themselves in order to provide direct benefits to humans (Gómez-Baggethun & Barton, 2013:240; Cilliers, 2015:85). Accordingly, as seen in **Table 4-1**, definitions regarding ESs have been defined by many authors, but are always expressed in an anthropocentric manner (Grunewald & Bastian, 2015:1) with reference to human benefits (Escobedo *et al.*, 2011: 2079; Osmond & Pelleri, 2017:34) and direct impacts on quality of life (health and security) in urban areas (Gómez-Baggethun & Barton, 2013:236; Grunewald & Bastian, 2015:1). However, Washington *et al.* (2017:35) stress that ecosystems also provide services (food, water, habitat, nutrients, and energy) to all other living species, and these too should be considered.

Box 3 illustrates the definition of ESs for the purpose of the research derived from the various authors indicated in **Table 4-1**.

Box 3: A definition for urban ecosystem services (ESs)
ESs could be considered as the benefits all living species (especially humans) derive, directly or indirectly, from the capacity (function) of ecosystems to provide goods and services that satisfy needs.

Source: Costanza *et al.* (1997:253); Bolund and Hunhammar (1999:297); de Groot *et al.* (2010:260); Costanza *et al.* (2017).

The “goods” and “services” derived from the urban ecosystem could according to both the Millennium Ecosystem Assessment (MA, 2005), as well as Cilliers *et al.* (2013:682) be considered together as “ecosystem services”.

According to Haines-Young and Potschin (2010:111) along with difficulty to arrive at a single definition for ESs, different authors have attempted to develop different classifications of ESs. A discussion on ESs classifications follows.

4.4 Identifying and understanding classification of ESs into categories

In 2005, the MA (2005) was the first to attempt to identify and categorise ESs according to their functions into four broad categories, namely: provisioning services; regulating services; cultural services and supporting services (Luederitz *et al.*, 2015:101; La Notte *et al.*, 2017:392). Followed by the MA's ESs categories, the TEEB report adopted, but adjusted the MA classification (Costanza *et al.*, 2011:14). For the purpose of this study, the ESs classification by TEEB (TEEB, 2010) is emphasised, dividing ESs into provisioning, regulating, cultural services and a further category, namely habitat services or supporting services (La Notte *et al.*, 2017:392). The four ESs categories and different ESs generated by GI elements (ecosystems) will be further elaborated upon in the upcoming sections of the chapter.

4.4.1 Provisioning ecosystem services

Provisioning ESs is considered as the capability of natural (e.g., rivers, biomes) or semi-natural (e.g., community gardens) green spaces to contribute to physical products (MA, 2005:56), materials (Haines-Young & Potschin, 2010:111) or goods (Hein *et al.*, 2006:62) consumed directly by humans (De Groot *et al.*, 2002:395; Grunewald *et al.*, 2015:13). According to the MA (2005:45) the consumption rate of provisioning ESs by humans is drastically increasing in an unsustainable manner. The direct benefits humans obtain from provisioning ESs depends on the availability of resources (Hein *et al.*, 2006:62), including food supply (Colding, 2011:229), freshwater (Gómez-Baggethun *et al.*, 2013:178), raw materials such as timber (MA, 2005:45), and medicinal plants (TEEB, 2010:3).

4.4.1.1 Food supply

Ecosystems provide conditions to produce a wide range of food products (TEEB, 2010:3), for instance meat and edible plants (MA, 2005:56). Food production in urban areas derive from natural ecosystems (e.g., agro-ecosystems, marine and freshwater systems, or forests) that provide wild plants and animals (De Groot *et al.*, 2002:400; TEEB, 2010:3). Additionally, food in urban areas could also be cultivated through urban agriculture (De Groot *et al.*, 2002:400).

Urban agriculture is described in section 3.3.2.2 as the cultivation of plants for food and the production of livestock within urban areas (RUAF, 2009; Lin *et al.*, 2017:115). Typically, urban agricultural GI elements would include for example sub-urban farms, on rooftops, in residential backyards, home gardens, through urban horticulture or employing community gardens (Gómez-

Baggethun *et al.* 2013). Lindley *et al.* (2018:338) emphasise that urban agriculture is the “life-line” for several poor societies struggling with food insecurity in urban Africa. Cilliers (2019c:6) observes that data from Statistics SA revealed that 70% of urban households in South Africa are confronted by food insecurity. Moreover, urban agricultural spaces would according to Du Plessis and Landman (2002:50) especially improve conditions in lower-income communities of South Africa. Food supplied by ES is considered crucial to urban food security to meet the food demands of urban dwellers and to provide them with a healthier diet (Langenmeyer, 2015:46). The ESs could furthermore generate an income for some vulnerable urban households when trading the goods in informal markets (Secretariat of the Convention on Biological Diversity, 2012:10).

According to Wilkerson *et al.* (2018:103) the demand for the food supply provisioning service will to a great extent depend on the needs and desires of people, influenced by their socio-economic characteristics. For instance, in South Africa, it was found that food supply in poorer neighbourhoods is considered a critical provisioning ESs (Schäffler *et al.*, 2013:250) and residents in these neighbourhoods tend to use their private home gardens or other green spaces for supplementary food production more frequently than those residents in socio-economically advantaged areas (Cilliers *et al.*, 2013:686). However, according to another study by Cilliers *et al.* (2018:298) the degree to which urban agriculture contributes to increased food security and alleviates poverty is “debatable”. Cilliers *et al.* (2018:298) referred to several studies indicating that home gardens contribute to household food security yet does not necessary contribute to overall sustainable food security of urban areas, resulting from a lack of space, water and insufficient skills and information regarding urban agriculture among communities.

4.4.1.2 Raw materials

Raw materials, such as wood, biofuels, plant oil, dung and other biological materials are delivered by wild and cultivated plant species in some natural and semi-natural green spaces, for instance urban forests (TEEB, 2010:3) and could be consumed as materials and used as fuel as energy sources (MA, 2005:56; De Groot *et al.*, 2002:401).

4.4.1.3 Freshwater

Ecosystems play a vital role in providing cities with freshwater for drinking and other human purposes (TEEB, 2010:3; Gómez-Baggethun & Barton, 2013:240). The ecosystems contributing to localised freshwater include all blue-green spaces (watercourses and catchment areas), for instance natural wetlands, ponds, rivers, and streams within city boundaries (Secretariat of the Convention on Biological Diversity, 2012:10).

The quality and availability of water provided by these blue-green spaces are influenced by the surface of urban areas (Gómez-Baggethun & Barton, 2013:240), for example freshwater resources are often degraded by urban surfaces when pollutants (e.g., organic sewerage, vehicle effluents, and plant fertilizer) accumulate within the water resources. Therefore, freshwater depends fundamentally on the regulating function of ecosystems (water storage, filtration, and drainage) (TEEB, 2010:3) and is interconnected and dependant on the “waste-water treatment” regulating services that will be discussed in section 4.4.2.4 (MA, 2005:57).

The adequate provision of freshwater provisioning services to meet society's needs are challenging (Gómez-Baggethun *et al.*, 2013:179). This is especially true in a “water-stressed” country, such as South Africa with well-known water supply and quality problems (Ashton & Ramasar, 2002).

4.4.1.4 Medicinal resources

Urban green spaces deliver some variety of plant species directly consumed by humans as traditional medicine or raw materials utilised as resources in the pharmaceutical industry (MA, 2005:57; TEEB, 2010:3). In Africa, up to 80% of the population still relies on medicinal resources such as plants, animals, or mineral-based medicines as preliminary health practices in a manner to address, treat, diagnose, or prevent illness (Zhang & World Health Organization, 2002:7). Moreover, medicinal plants are a significant source of income for many communities in African countries (Egoh *et al.*, 2012:73). A study by Langenmeyer (2015:182) on medicinal resources indicated that people also consume medicinal plants, such as herbs, grown in home gardens, for example rosemary for colds and disinfectants or aromatic plants for cooking. Both the studies of Maroyi and Mosina (2014:666) and Semenya and Potgieter (2014:128) also found that medicinal plants are often cultivated in South African home gardens. Home gardens are emphasised for easily accessible medicinal resources, as well as for alternative health care options when primary healthcare services are insufficient (Maroyi & Mosina, 2014:666). Semenya and Potgieter (2014:128) furthermore emphasise the establishment of community-nurseries, where communities could grow medicinal plants.

4.4.2 Regulating ecosystem services

Regulating services include the range of environmental functions or processes carried out by ecosystems (MA, 2005:58; Haines-Young & Potschin, 2010:111; Chen, 2017:184). In the same line, Anderson *et al.* (2016:446) consider regulating services as the services obtained from the functions of ecosystems, including the services of regulating the climate, the removal of pollutants by air and water filtration (Colding, 2011:229), seed dispersal and pollination (Anderson *et al.*, 2016:446), and water storage, filtration, and drainage (Williams *et al.*, 2009:4), protection from

disasters such as landslides and other natural storm or providing pest and human disease regulation (TEEB, 2010:3; Gómez-Baggethun *et al.*, 2013:178). These services obtained from the functions of ecosystems has a direct impact on the direct benefits to humans (De Groot *et al.* 2002; Hein *et al.*, 2006). Seeing that regulating services indirectly benefit humans, these services are less obvious to the general public (Langenmeyer, 2015:45). Moreover, humans and their anthropogenic activities have a direct and compelling influence on regulating services through the modification of green spaces and the services they provide through land-use changes and increasing the number of greenhouse gasses released into the atmosphere (MA, 2005:58; Anderson *et al.*, 2016:446).

4.4.2.1 Local climate regulation

According to the MA (2005:58) ecosystems could regulate the climate at both local and global scale. At a local scale, temperature, and rainfall of urban areas are affected by the surfaces of urban spaces (MA, 2005:58; Pickett *et al.*, 2011:333; Osmond & Pelleri, 2017:31). A well-known anthropogenic climate modification is the urban heat island (UHI) effect (Bowler *et al.*, 2010:150). UHI is responsible for the higher temperatures in urban areas compared to surrounding rural areas, especially at night (Bowler *et al.*, 2010:150; Osmond & Pelleri, 2017:31). At local scale, GI has the ability to regulate climate change in urban areas (Molla, 2015:97). Ecosystems, especially different GI elements (both blue and green spaces), reduce the UHI by absorbing heat in the summer via water areas and vegetation (evaporative cooling) and releasing heat again in the winter (Bolund & Hunhammar, 1999:296; Gómez-Baggethun & Barton, 2013:240). Green roofs and street trees have been identified as a particular GI element important for the regulation of local climates by cooling buildings and shading urban surfaces in the summer and blocking cold winds in the winter causing a decrease in energy use for air conditioning and accompanied greenhouse gas emissions (Gómez-Baggethun & Barton, 2013:240).

Local climate is furthermore influenced by anthropogenic termination of urban surfaces as rainwater infiltration is reduced with limited water reaching groundwater reserves (Dawe, 2010:427). Moreover, the flow and structure of natural watercourses are influenced. This is also known as the “urban-stream syndrome” (Pickett *et al.*, 2011:335). However, with the presence of GI elements such as urban forests and street trees, rainwater runoff in urban areas is reduced and captured, forming evapotranspiration and rain formation (Dawe, 2010:427). Bolund and Hunhammar (1999:297) mentioned the same regarding other vegetated green spaces and their underlying soils that infiltrate rainwater and release it again through evapotranspiration.

On a global scale, the climate is influenced by the emission of greenhouse gasses and other pollution through urban activities (e.g., industries, transportation, domestic heating, and waste

incineration) (Gómez-Baggethun & Barton, 2013:240; Osmond & Pelleri, 2017). Ecosystems regulate air quality on a global scale through carbon sequestration storage (MA, 2005:58).

4.4.2.2 Air Purification (Carbon sequestration storage)

The vegetation of GI elements acts as “carbon stores” (TEEB, 2010:3) by extracting pollutants and chemicals from the atmosphere and storing and filtering greenhouse gases in plant “tissues” (MA, 2005:58; Gómez-Baggethun & Barton, 2013:240). In the study of Molla (2015:95) it was discovered that GI elements such as green roofs, Bioswales, and trees, capture and purify carbon dioxide (CO₂), dust, soil, and other particulates in urban air. According to Bolund and Hunhammar (1999:296) trees present an especially high capability to filter air, for instance, 1 hectare of trees could remove up to 15 tons of particulates per year. However, Molla (2015:96) claims the ability of trees to filter air varies between species, the age of the tree, and with the planting design. Nevertheless, urban air quality is improved by the removal, storage, and filtration of these particulates through GI elements (Bolund & Hunhammar, 1999:296; MA, 2005:58) advancing human health by decreasing the risk of respiratory and cardiovascular diseases (Gómez-Baggethun & Barton, 2013:240).

4.4.2.3 Moderation of Environmental Extremes

Pelling (2003:29) claims urban areas are increasingly becoming centres of environmental hazards and a risk for their residents. This is seeing the fact that urban areas are experiencing rapid urbanisation and population growth (Jayakody *et al.*, 2016:147). Those urban areas that are especially prone to environmental hazard include the areas located near floodplains that are vulnerable to hazards such as mud slides or flash floods (Pelling, 2003:33). Other urban areas could experience environmental hazards such as heatwaves and droughts (Pelling, 2003:34). Literature emphasises the role of urban planning to implement planning and design interventions to yield cities resilient to disaster (Jayakody *et al.*, 2016:147). Foster *et al.* (2011:50) suggests a GI planning approach incorporated in the planning and designing of urban areas for a more resilient manner. Other authors also emphasise the importance of GI in urban areas as a mitigation strategy and claim the presence of green spaces in urban areas act as natural barriers to reduce the damage of effects caused by extreme environmental events (MA, 2005:58; TEEB, 2010:3; Govindarajulu, 2014:37). For instance, Gómez-Baggethun and Barton (2013:240) discovered the vegetation and soil of green spaces stabilise land, preventing the occurrence of landslides. Green roofs are indicated as an effective GI element for flood mitigation seeing that these roofs could retain more rainfall than conventional roofs (Liao *et al.*, 2017:208). Floods in urban areas could be furthermore mitigated through GI elements such as Bioswales, rain gardens, and natural spaces such as rivers and wetlands, that reduce surface runoff by accumulating high

levels of water (Ossola *et al.*, 2015:1). Furthermore, the effects of urban heat waves could be mitigated through the evapotranspiration and cooling effects of the vegetation of GI elements (Gómez-Baggethun & Barton, 2013:240; Chen, 2017:191). Empirical evidence indicates that planting more urban trees is considered as one of the most cost-effective strategies to mitigate heat in urban areas (Livesley *et al.*, 2016:119).

4.4.2.4 *Waste-water treatment*

GI elements, specifically the blue-green spaces, also have the ability to improve water quality by filtering out, decomposing, and retaining nutrient pollutants and other organic wastes within the water (MA, 2005:58; Gómez-Baggethun & Barton, 2013:240). This is possible seeing that the biological process of microorganisms in the soil of the blue-green spaces ensure that waste is broken down, reducing levels of nutrients and pollution within the water resource (TEEB, 2010:3). Water regulation ESs is of especially high value in arid and semi-arid regions (Egoh *et al.*, 2012:72).

4.4.2.5 *Pollination*

Pollination is a free service provided in both natural and man-made GI elements (Daily *et al.*, 1997:10). Obute (2010:002) defines pollination as the “*transfer of pollen to a flower or plant that allows fertilisation*”. Animal and insect species including bats, bees, beetles, birds, butterflies, and flies, as well as wind and water are responsible for pollen distribution, essential for reproducing both wild plants and agricultural crop species, for example fruits, vegetables, and the dispersal of seeds for food production (Daily *et al.*, 1997:10; MA, 2005:58; TEEB, 2010:3; Niemelä *et al.*, 2010:3230; Gómez-Baggethun *et al.*, 2013:240). GI elements such as domestic gardens and public gardens (e.g., botanical, or horticultural gardens) contribute to pollination services in urban areas (Chen, 2017:190). Animal pollination, especially bees (and some birds and bats) are indicated in literature as crucial to provide adequate pollination services for urban agriculture, as well as for plant species necessary for pharmaceutical practice within urban areas (Jansson & Polasky, 2010:20; Chen, 2017:190).

4.4.2.6 *Biological control*

According to van Lenteren (2006:103) biological control is a natural approach to control the number of pests and diseases for example herbivorous insects, rodents, fungi, snails, and viruses, in urban areas. Pest and diseases are a threat to urban ecosystem functioning, as well as human health (Chen, 2017:189). For instance, without the biological control offered by ESs, the production of energy, and the growth of plants for food are threatened (van Lenteren, 2006:103). Both MA (2005:58) and TEEB (2010:3) claim that ecosystems can regulate pests and diseases

through the activities of predators and parasites. Birds, bats, flies, wasps, frogs, and fungi occurring in different ecosystems act as natural controllers to regulate pests and diseases (TEEB, 2010:3).

4.4.2.7 Erosion prevention and maintenance of soil fertility

Surface-protected soil by ways of vegetation cover, for instance trees and other plant root systems or plant leaves (Gómez-Baggethun *et al.*, 2013:240) stabilises soil and in return controls soil erosion and prevents landslides or mudslides (MA, 2005:58; TEEB, 2010:3; Comerford *et al.*, 2013:7).

Moreover, the maintenance of soil fertility regulation services provided by ecosystems is essential for the provisioning service (c.f. section 4.4.1) through recycling “waste”, such as leaf fall into a useable resource for plant growth (Comerford *et al.*, 2013:7) or through organic nitrogen that is broken down by soil organisms and supply the soil with nutrients to be reutilised for plant growth (TEEB, 2010:3).

4.4.3 Cultural ecosystem services

Cultural ESs are classified as the non-material benefits obtained from ecosystems that aid the cultural or spiritual needs of humans (MA, 2005:58; Haines-Young & Potschin, 2010:111; Gómez-Baggethun *et al.*, 2013:178). Seeing that cultural ESs are non-material benefits, people obtain the benefits of the ESs upon actual visits to a GI element providing cultural ESs (Hein *et al.*, 2006). Cultural ESs could enhance the quality of the urban living environment when these services are experienced (Hein *et al.*, 2006). GI elements, such as urban parks, as well as other green spaces in urban areas are considered “hotspots” for cultural ESs (Charoenkit & Piyathamrongchai, 2019:1).

The demand for cultural ESs is not homogeneous across any individual city, being tightly linked to peoples’ needs and desires, experiences, human values, and behaviour (Hein *et al.*, 2006; Wilkerson *et al.*, 2018:103; Charoenkita & Piyathamrongchaib, 2019:1). Wilkerson *et al.* (2018:103) further acknowledge that the socio-economic background of people (factors such as income, wealth, education, and ethnicity in particular influence their desires and perceptions. Thus, MA (2005:58) recognises that perceptions of the cultural ESs differ among individuals and communities. The cultural services that identified by literature and will be discussed, include cognitive development, recreation, and aesthetic experiences, spiritual enrichment, tourism opportunities, as well as supporting knowledge systems and meeting points for various social groups (Hein *et al.*, 2006; Colding, 2011:229; Gómez-Baggethun *et al.*, 2013:178; Molla, 2015:37).

4.4.3.1 Recreation and cognitive development

Urban green spaces are tied to outdoor activities providing multiple recreational opportunities for physical exercise, to play, to rest and to relax (Bolund & Hunhammar, 1999:297; Secretariat of the Convention on Biological Diversity, 2012: 10; Gómez-Baggethun & Barton, 2013:240; Feng & Tan, 2017:46). Several authors recognise these recreational opportunities as the highest valued ecosystem services in cities (Bolund & Hunhammar, 1999:297; Gómez-Baggethun *et al.*, 2013:178).

Daily *et al.* (1997:11) claim that people have a deep appreciation for nature and choose to spend their time based on the natural characteristics of the ecosystem (MA, 2005:58). Moreover, Gómez-Baggethun *et al.* (2013:178) believe factors such as accessibility, safety, privacy, and comfort will vary according to a social criterion (based on peoples' needs and desires, experiences, human values, and behaviour, socio-economic background) and in the same line also influence their decision to spend time in a particular green space (De Groot *et al.*, 2002:402).

Along with the opportunity for outdoor activities, exposure to ecosystems also provide the opportunity for cognitive development and education for both young children and adults (Gómez-Baggethun & Barton, 2013:240; Elmqvist *et al.*, 2015:105). Both formal and informal educational opportunities are provided by ecosystems and their components (MA, 2005:59). GI are especially recognised to provide valuable educational opportunities (Molla, 2015:93). The education provided by GI could include including local ecological knowledge learned through school fieldtrips (Elmqvist *et al.*, 2015:105) or by informally visiting the green spaces with family or friends (Molla, 2015:93). More formal education provided by some GI elements includes “field laboratories” for scientific research (De Groot *et al.*, 2002:402). Ecological knowledge among the general public is important for an increased awareness, respect and appreciation regarding the natural environment and stronger recognition of the potential ecosystem services have for urban dwellers mental and physical health (Gómez-Baggethun *et al.*, 2013:178; Secretariat of the Convention on Biological Diversity, 2012: 10; Molla, 2015:93).

4.4.3.2 Aesthetic appeal

According to Chen (2017:190) and Feng and Tan (2017:44) GI elements can produce high quality environments, well-known for their aesthetic role in “softening” the hard, grey, and monotonous buildings and infrastructure of urban areas. It is Daily *et al.* (1997:11) that claims nature in urban areas provide an “*unparalleled source of wonderment and inspiration, peace and beauty, fulfilment, and rejuvenation*”. Therefore, people tend to visit green spaces to reflect on their feelings (Tzoulas *et al.*, 2007:171), or to enrich human life with meanings and emotions that

contribute to their mental health (TEEB, 2010:3; Gómez-Baggethun & Barton, 2013:240). Moreover, the aesthetic values of urban areas tend to enhance walking and biking that further reduce pollution effects from transportation (Molla, 2015:93). Tzoulas *et al.* (2007:171) discovered the aesthetic appeal ESs of GI element nearby offices and residential apartments tend to enhance the mental health of people. Various aspects of green spaces contribute to the beauty and aesthetic values of urban areas that attract visitors and tourists and provide inspiration for books, magazines, film, photography, art, and architecture (De Groot *et al.*, 2002:402; MA, 2005:59; TEEB, 2010:3). Feng and Tan (2017:46) further emphasise the significance of considering aesthetic ESs by claiming that the ESs creates a favourable image for a place that is essential for investment opportunities. Accordingly, Molla (2015:93) acknowledges for instance that housing developments near well-maintained green spaces are more attractive for house buyers (Molla, 2015:93).

4.4.3.3 Spiritual experience and sense of place

Certain groups in society attach spiritual significance and religious meaning to ecosystems (MA, 2005:58) or to their components, such as animal products (e.g., skins and shells), sacred caves or mountains (TEEB, 2010:3; Feng & Tan, 2017: 49), holy forests, ancient waterfalls, or old trees (De Groot *et al.*, 2002:402). A number of plant species and more specifically their flowers hold cultural significance (Feng & Tan, 2017: 49; MA, 2005:57).

TEEB (2010:3) and Gómez-Baggethun and Barton (2013:240) state that ecosystems could contribute to a “sense of belonging” or “sense of place” for people. According to Cross (2001:1) a persons’ sense of place attachment relates to a personal perception or emotional meaning toward a place. People tend to feel attachment toward environments or aspects of green spaces that are familiar to them (MA, 2005:59). A sense of place could furthermore be related to peoples’ cultural beliefs and practices associated with a place (Cross, 2001:1). In line with this, Molla (2015:92) recognises that green spaces serve as a nearby resource for people to escape from the rush of city life and provides them with a peaceful and safe place in a natural environment for relaxation and meditation (Feng & Tan, 2017:49).

4.4.3.4 Tourism

Ecosystems provide the opportunity for many sorts of tourism (TEEB, 2010:3). The large numbers of biodiversity and variety of animal species, including birds, butterflies, and other species accommodated by ecosystems are an attraction for many urban dwellers (Gómez-Baggethun & Barton, 2013:240). Moreover, tourism ESs depends on the other cultural ESs previously discussed, seeing that recreational opportunities, aesthetic appreciation, and sense of place or

religious experiences attract tourists to different green spaces (Pueyo-Ros, 2018:111). The tourism ESs does not only benefit humans but also presents economic value to private companies and community hosts (Pueyo-Ros, 2018:111), therefore contributing a vital source of income for many communities (TEEB, 2010:3). Some ecosystems also provide the opportunity for “Eco-tourism” (De Groot *et al.*, 2002:402), that is defined as the traveling to undisturbed natural conserved areas (e.g., nature reserves) with the specific objective to enjoy the scenery (Chiutsi *et al.*, 2011:15) or for educational purposes (TEEB, 2010:3). South Africa is a significant eco-tourism destination given its abundant natural resources and urban biodiversity hotspots for instance the Cape Floristic Region global biodiversity hotspot (Cape Town) with a richness of floral species (Holmes *et al.*, 2012:28). The Big Five and many available bird species in numerous National Parks (Chiutsi *et al.*, 2011: 20) also attracting visitors and significant income (Egoh *et al.*, 2012:73).

4.4.4 Habitat and supporting ecosystem services.

According to Haines-Young and Potschin (2010:111) habitat services (or supporting services as mentioned by the MA, 2005) do not directly benefit humans (Liquete *et al.*, 2016:250), however, they underpin the fulfilment of all the other ESs discussed above. In other words, the habitat and supporting ESs category are essential for ecological functions and processes to occur to produce all of the other ESs (Haines-Young & Potschin, 2010:111; Gómez-Baggethun *et al.*, 2013:178; Liquete *et al.*, 2016:250). This category of ESs includes the delivery, for example provisioning of habitat for species (MA, 2005:59; TEEB, 2010:3; De Groot *et al.*, 2002:396) and genetic diversity (TEEB, 2010:3).

4.4.4.1 Habitats for species

Along with the fact that cities are a habitat for humans, it is also a habitat for several plant and animal species (Werner & Kelcey, 2017:132). Ecosystems within cities constitute of habitats for wild plants and animals utilised for both refuge and reproduction (De Groot *et al.*, 2002:396). The functions of habitats are according to De Groot *et al.* (2002:400) divided into two subcategories, namely “refuging function” and “nursery function”. The latter will be discussed in section 4.3.4.2 - genetic diversity.

The refuging function of natural ecosystems as habitats refers to the ability of ecosystems to provide habitat (or living space) with elements, for instance, food, water, and shelter that are necessary for a plant or animal species to survive (Gómez-Baggethun *et al.*, 2013:178; Liquete *et al.*, 2016:250). According to Niemelä *et al.* (2010) spatial planning should consider how much of each habitat should be conserved in order to maintain certain species or biological process. Specifically, GI elements have been pointed out to have the ability to provide habitats for species

in urban areas (Molla, 2015:95). Moreover, a network of GI serves an important role in reconnecting habitats, by creating green areas in close proximity to one other and an essential physical space for ecological functions to occur (De Groot *et al.*, 2002:400; Niemelä *et al.*, 2010:3230; Molla, 2015:95). According to De Groot *et al.* (2002:400) these spaces provide the foundation for all the other ecosystem goods and services.

4.4.4.2 Genetic diversity

Genetic diversity is defined by TEEB (2010:10) as the variety of genes between, and within a population of species. So, the more species in a habitat, the higher it is genetic diversity will be. The nursery function of ecosystems as identified by De Groot *et al.* (2002:400) refers to the ability of natural ecosystems to provide breeding areas for species in order to contain a remarkably high number of species or also referred to as “habitat genetically diversity” (Liquete *et al.*, 2016:250). The maintenance of ecosystems as healthy habitats for wild plants and animals (as discussed in the previous section) is necessary for the effective breeding and reproduction of genetic diversity (De Groot *et al.*, 2002:400).

According to Molla (2015:97), GI elements provide habitats for a wide range of flora and fauna and could, therefore, be seen as a “storehouse” of genetic diversity (Secretariat of the Convention on Biological Diversity, 2012: 11) and some even as “biodiversity hotspots” as mentioned by TEEB (2010:10). According to Haines-Young and Potschin (2010:111) “biodiversity” per se is not a service, however, there is strong evidence that biodiversity is intricately linked to the functioning of ecosystem processes (Liquete *et al.*, 2016:250; Mascarenhas, 2017:9) that further influence the supply of other ESs (MA, 2005:57). Daily *et al.* (1997:2) also considers biodiversity as the main source for the availability of ecosystem goods. Accordingly, Schwartz *et al.* (2000:298) pointed out that a positive relationship exists between the level of species richness (biodiversity) and some of the ecosystem’s functions. The study claims that a diversity of species must be conserved for certain ecosystem functions to be delivered, for instance, productivity functions necessary for provisioning ESs, and nutrient cycling essential to provide some regulating ESs (e.g., for soil fertility) (Schwartz *et al.*, 2000:304; Haines-Young & Potschin, 2010:119). Mascarenhas (2017:9) therefore believes the planning and management of green spaces for the conservation of biodiversity is essential in order to directly provide other ESs that could meet human needs.

Table 4-2 summarises the ESs categories and their accompanied ESs as discussed in this section.

Table 4-2: Summary of urban ecosystem services classification.

Habitats for species	Habitat and supporting services	Provisioning ecosystem services - the services that describe the physical products, materials, and goods derived from ecosystems and are directly consumed by humans.	
The ability of ecosystems to provide a healthy habitat (or a living space) with elements, for instance food, water and shelter that are necessary for a plant or animal species for effective breeding and reproduction. These healthy habitats and their species form the foundation of conditions essential for ecological functions and process to occur in order to produce all of the other ESs.		Food supply	Conditions to produce a wide range of food products, including wild edible plants and animals or privately cultivated products in peri-urban farm, on rooftops, in residential backyards, or community gardens (urban agriculture).
		Raw materials	Material such as fibre, timber, wood, biofuels, plant oil, dung, and other biological materials are delivered by wild and cultivated plant species in some GI elements (e.g., urban forests), utilised for construction or as a source of energy (fuel-firewood).
		Fresh water	Fresh water for drinking and other human purposes through watercourses and catchment areas, for instance GI elements such as wetlands, ponds, rivers, and streams. Urban surfaces (both anthropogenic and vegetated) influence the quality of water.
		Medicinal resources	A variety of plants species or other raw materials directly consumed by humans as traditional medicine or as resources for the pharmaceutical industry, for example biochemical products or herbs.
		Regulating services - the indirect services that ecosystems derive by the range of environmental functions or process carried out by the ecosystems.	
		Local climate regulation	Ecosystems (including all green and blue spaces) regulated urban climate by absorbing heat, trees that shade urban surfaces, reduce rainwater runoff, infiltrate rainwater and, releases it through evapotranspiration.
		Air Purification (Carbon sequestration storage)	Vegetation of GI elements (ecosystems) acts as “carbon stores”, extracting pollutants, capturing (fine) dust, and chemicals from the atmosphere, storing and filtrating it through vegetation and releasing it as oxygen.
		Moderation of Environmental Extremes	Some GI elements could act as natural barriers that reduce the damage of effects caused by extreme climate events, hazards and storms, and flood prevention. The cooling effect of GI element’s accompanied vegetation also mitigate the effects of heat wave effects.
Genetic diversity		Waste-water treatment	Blue-green spaces GI elements are responsible for generating quality water by filtrating out, decompose and retain nutrient pollutants and other organic wastes found in urban water resources (watercourses and catchment areas).
The ability of natural ecosystems to provide breeding areas for species in order to contain a remarkably high number of species that assembles habitat genetic a diversity. Also, referred to as “biodiversity hotspots”. A high biodiversity is an essential source for the functioning of ecosystem processes that further influence the availability and supply of other ESs.		Pollination	The transfer of pollen by means of insects and other animal species essential for reproducing both wild plants and agricultural crop species and the dispersal of seeds for food production.
		Biological control	The ability of ecosystems to control the number of pests and diseases for example herbivorous insects, rodents, fungi, snails, and viruses through the activities of predators and parasites for example birds, bats, flies, wasps, frogs, and fungi.
		Erosion prevention and maintenance of soil fertility	Surface-protected soil by way of vegetation cover for instance trees and other plants root systems or tree leaves stabilises soil and in return control soil erosion and preventing landslides or mudslides, creating a stable environment for other ecosystem services.
		Cultural services - non-material services obtained upon visits to an ecosystem and benefiting the cultural or spiritual needs of humans.	
		Recreation and cognitive development	Ecosystems provide multiple outdoor recreational opportunities for physical exercise, to play, to rest and to relax. Furthermore, the opportunity for cognitive development and both formal (e.g., scientific research) and informal (e.g., school trips) ecological education.
		Aesthetical	Biodiversity and the natural landscape of GI elements are well-known for their aesthetic role in “softening” the hard dominated grey monotonous buildings and infrastructure of urban areas or furthermore provides inspiration for books, magazines, film, photography, art paintings and architecture.
		Spiritual experience and sense of place	Certain groups attach spiritual significance and religious meaning to ecosystems or to their components, such as animal products (e.g., skins and shells), sacred caves or mountains, worship of holy forests, ancient water falls, or old trees or flowers have cultural related significance to people create a “sense of belonging” or “sense of place” for people.
	Tourism	Depends on the other cultural ESs seeing that recreational opportunities, aesthetical appreciation and sense of place or religious experiences attracts tourists to different ecosystems. Also, “eco-tourism” provides a number of biodiversity and variety animal species conveyed by ecosystems as an attraction for many tourists.	

Source: Own construction based on various source utilised in section 3.3.

The purpose of **Table 4-2** is to describe and convey ESs and their categories to an urban planning audience who may not be familiar with the concept and the potential. The table also serves as the criteria of ESs that will be assessed in the empirical investigation of the study (Section B, Chapter 6). Alongside the multiple benefits discussed in **Table 4-2**, urban ecosystems also generate threats and nuisances, referred to as “ecosystem disservices” (ESDs) (Lyytimäki & Sipilä, 2009:309; von Döhren & Haase, 2015:490). The chapter will elaborate on ESDs in the following section.

4.5 Considering Ecosystem Disservices

EDSs may occur in various forms (von Döhren & Haase, 2015:490) and could be perceived as environmental costs or social nuisances, that are negative and harmful to human well-being (Escobedo *et al.*, 2011:2079) or unwanted by citizens seeing that it could have financial costs (Cilliers *et al.*, 2013:683; Chen, 2017:192).

Potential ecosystem disservices from urban green spaces (ecosystems) include financial (economic) costs, such as the costs for the control or removal of unwanted invasive species (e.g. insects, weeds, birds and small mammals) (Lyytimäki & Sipilä, 2009:309), physical damage and maintenance costs to maintain green spaces or repair costs of urban infrastructure damaged by, for example tree roots, bird excrement, or animal digging and nesting holes (Lyytimäki *et al.*, 2008:163; Escobedo *et al.*, 2011:2079; Lovell & Taylor, 2013:1447).

Moreover, EDSs negatively affect human health (von Döhren & Haase, 2015:490) referred to as a “social nuisance” including the spread of allergenic pollen in flowering season (Chen, 2017:190) that causes health problems for people with respiratory conditions such as asthma (Lyytimäki *et al.*, 2008:163) or diseases from plants or animals (Lovell & Taylor, 2013:1447). Some plants also cause air pollution (Chen, 2017:192) by means of the emission of volatile organic compounds (VOC) (Escobedo *et al.*, 2011:2079). Tzoulas *et al.* (2007:171) recognised that cultural EDSs has a psychological impact on humans (von Döhren & Haase, 2015:490) for instance when people are fearful or discomforted by densely grown or dark green spaces, especially at night-time (Lyytimäki *et al.*, 2008:163).

According to Lyytimäki *et al.* (2008:161) EDSs influence how urban green areas are experienced and valued. In contrast with the aesthetic functions of some ESs (c.f. 4.4.3.2), EDSs delivers aesthetic disservices (Lyytimäki *et al.*, 2008:163). According to Benedict and McMahon (2012:3) contemporary urban planning tends to consider green spaces only as a “fill in the gap” strategy. The result is that green spaces are not effectively managed causing a negative image, for instance parks with weeds and dense vegetation are often considered useless, unpleasant, or

unsafe (Lyytimäki *et al.*, 2008:163). Consequently, Lyytimäki and Sipilä (2009:309) claim properties in proximity to these under-maintained green spaces tend to have lower property values. Cilliers and Cilliers (2015) investigated the proximity principle in Potchefstroom (South Africa) whether properties near green spaces have higher values than those further away, as in cities in developed countries. Their results indicated that properties located adjacent to green spaces had lower values than properties located further away seeing some EDSs of crime rates and noises (Cilliers & Cilliers, 2015:15).

Table 4-3 provides a summary of various EDSs discussed above, as well as other EDSs mentioned by authors. The EDSs are categorised as argued by Lyytimäki & Sipilä (2009), Escobedo *et al.* (2011) and Cilliers *et al.* (2013) under the “costs” that EDSs have that are negative and harmful to human well-being.

Table 4-3: Examples of ecosystem disservices in urban areas.

CATEGORY	ECOSYSTEM DISSERVICE	EXAMPLE
Financial cost	1. Physical damage to infrastructure	Urban infrastructure that gets damaged by, for example tree roots, bird excrement, or animals' digging and nesting holes.
	2. Invasive alien species nuisances	Costs for the control or removal of unwanted invasive species (e.g., insects, weeds, birds, and small mammals).
	3. Blockage of view	Blockage by tall trees standing close to buildings. Also blocking sunlight causing an increased energy use (air conditioning).
Social nuisances	1. Allergies	The spread of allergenic pollen by wind-pollinated plants in flowering season.
	2. Diseases	Diseases from plants or animals (e.g., rabies).
	3. Accidents	Fear of safety hazards from tree fall.
	4. Fear	A psychological impact when individuals are discomforted by for instance by densely grown or dark green spaces, especially in the night-time.
	5. Unmanaged green spaces (decreased aesthetics).	Green spaces such as parks with weeds and dense vegetation are often considered useless, unpleasant, or unsafe.
	6. Habitat competition with humans	Attraction of wild animals causes annoyance (e.g., damage to structures and ornamental plants) fear of sounds, or animal excrements or plant litter causing smells.
Environmental costs	1. Disturbance	Introduction of invasive species or displacement of native species.
	2. Water quantity and quality	Water run-off poisoning through accumulating fertilizer and pesticide in water resources.
	3. Air quality	Some plants cause air pollution by means of the emission of volatile organic compounds and secondary aerosol emissions.

Source: Tzoulas *et al.* (2007); Lyytimäki and Sipilä (2009); Escobedo *et al.* (2011); Gómez-Baggethun and Barton (2013); Lovell and Taylor (2013); Beumer and Martens (2014); von Döhren and Haase (2015); Chen (2017).

According to Lyytimäki and Sipilä (2009:311) the EDSs mentioned in **Table 4-3** are not static. Some disservices could change, and some may be considered as irrelevant or as minor nuisances based on context. Shackleton *et al.* (2016:582) provide the example that some people could find a tree aesthetically pleasing, while others could be allergic to it. Accordingly, EDSs are highly dependent on the biophysical and sociological context of an ecosystem, including the values, beliefs, and traditions of the affected societies or groups (Lyytimäki & Sipilä, 2009:311). Furthermore, socio-demographic factors such as different age groups and levels of education influence peoples' perceptions regarding EDSs differently (Lyytimäki *et al.*, 2008:169). Therefore, both Zhang *et al.* (2007:798) and Lyytimäki *et al.* (2008:169) recommend a public participation approach to locally determined EDSs of particular green spaces as perceived by affected societies or socio-demographic groups (Cilliers *et al.*, 2013:686).

While the first part of the chapter explored the terminologies and benefits of the ESs concept, as well as EDSs, the second part of the chapter will investigate the “knowledge-implementation gaps”, investigating and understanding the current use and uptake of the ESs concept in urban planning practice (Sitas *et al.*, 2014:3803).

4.6 Considering the ecosystem services concept within the urban planning practice

Urban areas traditionally consume ecosystem services (ESs); however, they also have the ability to produce ESs (Steiner, 2016:108) if urban planners enhance green space provision (Lyytimäki *et al.*, 2008; Cilliers & Cilliers, 2016:2). The preservation and enhancement of green spaces and their associated ESs ultimately depend on the importance they are ascribed in urban planning practice (Langenmeyer *et al.*, 2016:45).

4.6.1 The acknowledgement of ESs in urban planning practice

Both the authors, De Groot *et al.* (2010) and La Rosa (2019:1), acknowledge that the ESs concept remains a fragmented and still debated field in everyday planning and decision-making worldwide. This could be attributed to the fact that the concept was only recently introduced and evolved in urban planning practice (Steiner, 2016:108). Many planners are still sceptical and unfamiliar with the broad spectrum of ESs (Albert *et al.*, 2014:1303; Steiner, 2016:108) as ESs is generally absent in urban planning education (La Rosa, 2019:1). Also, the reliance on green spaces for delivering these ESs tend to be misunderstood (Cilliers & Cilliers, 2016:2).

According to Di Marino *et al.* (2019:645), some ESs generated from green spaces are more familiar to urban planners than others. Indeed, some regulating ESs are more familiar to urban planners as they deal with typical urban issues, for instance storm water management and air pollution (Di Marino *et al.*, 2019:645). Another ESs reported to be well-known to urban planners

is the cultural ESs category (c.f. section 4.4.3) (Anderson *et al.*, 2016:446). Therefore, according to Chen (2017:190) the recreation, aesthetics, and eco-tourism ESs are the most frequently emphasised in urban planning practice. However, according to Tan (2017:18) planning for spaces in urban areas should extend beyond aesthetic values, it should deliver multiple ESs to benefit human well-being and to contribute to environmental quality.

Planning decisions have the ability to foster healthier cities and environments (UN-Habitat and World Health Organization, 2020: v) when recognising the relationship between ESs and human well-being (Woodruff & Ben Dor, 2016:97). The MEA (2005:78) recognises the vital importance of ESs to human wellbeing. The MEA's (2005) outlook regarding ESs and the contribution it presents to human well-being is illustrated in **Figure 4-2**.

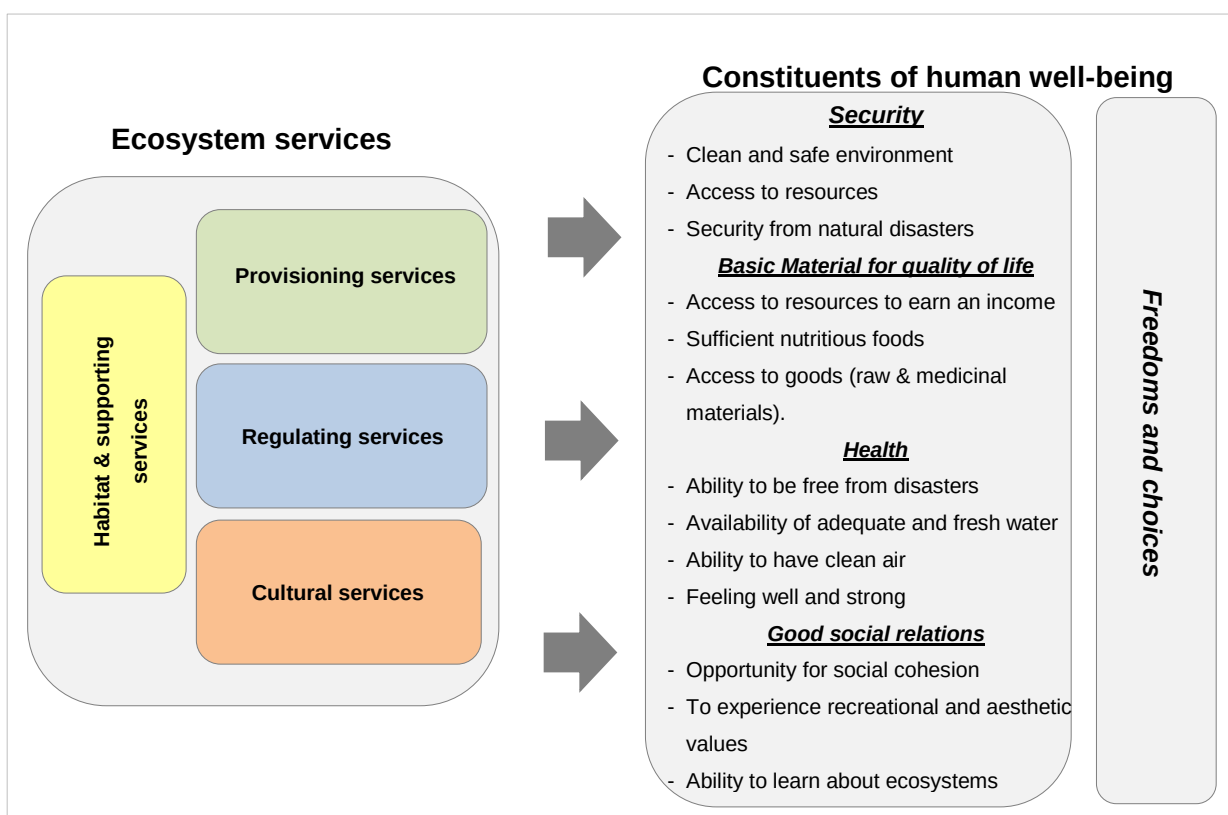


Figure 4-2: Ecosystem Services and their links to human well-being.

Source: Own construction based on MEA (2005).

Woodruff and Ben Dor (2016:97) also recognises the integration of ESs in urban planning could improve urban planning. Accordingly, when considering **Figure 4-2**, it could be seen that many of those services urban planning strives to facilitate and distribute to the general public, for example storm-water and disaster management and providing recreation facilities (Sitas *et al.*, 2014:3805) are freely provided by urban ecosystem systems to enjoy on a day-to-day basis (as discussed in section 4.4) (Colding, 2011:229). Thus, Tan (2017:18) suggests that the optimisation of ESs should be a “target” to be achieved in urban planning, rather than to incidentally plan for it in urban

areas. TEEB (2011) suggested a “six-step approach” for decision-makers, such as urban planners, to account for ESs in urban management and decision-making (Berghöfer *et al.*, 2011:11). The six-steps are suggested as follows; **Step 1** the decision-maker identifies a specific problem or policy issue by consulting with a variety of stakeholders (e.g., officials, general public, community groups and volunteers), followed by **Step 2**, in which the decision-maker then specifies whether or not the issue could be solved by ESs and the ESs that are the most relevant and central to the specific issue. In **Step 3**, it is suggested by Berghöfer *et al.* (2011:11) to gather comprehensive information needed on the ESs related to the issue and to decide on an assessment method for the valuation of the ESs. Thereafter, the assessment method should be implemented in practice along with how the ESs could benefit the issue or to identify any future changes in the ESs (**Step 4**). **Step 5** is to compare the gathered different management options and to select the most sufficient option related to the identified issue. **Step 6** then involves investigating the impact (negative or positive) of the decision on a range of stakeholders (Berghöfer *et al.*, 2011:11).

However, according to Di Marino *et al.* (2019:644) the concept of ESs does not automatically find its way into mainstream planning practices. Niemelä *et al.* (2010:3239) recommends firstly to build a “knowledge foundation” based on ESs for urban planning practice.

4.6.2 Considering the ESs knowledge of urban planners and their environmental worldviews

Niemelä *et al.* (2010:3239) acknowledge the importance of investigating the terminologies and benefits of ESs, but in addition emphasise the importance of studying the views and knowledge of planning practitioners regarding ESs. Both Mascarenhas *et al.* (2014:1287) and La Rosa (2019:1) also claim that considering the views and knowledge of planning practitioners pertaining to ESs are critical seeing that the integration of ESs is unlikely to occur without uncovering the barriers or challenges preventing urban planners from integrating ESs. Mascarenhas (2017:26) suggests asking the following questions in order to comprehend urban planners’ knowledge regarding the ESs concept: 1) *what is the level of awareness and knowledge that planners have about ESs*; 2) *what is the perceived level of current ESs integration in the planning process*; and 3) *what are the main factors that either facilitate or obstruct that integration?* (Mascarenhas, 2017:26).

It is further questionable if planners’ “conservation” or environmental worldviews could influence their decisions on incorporating ESs into urban planning practice. The term environmental worldview (also recognised as an environmental paradigm) refers to the “lens or filter” through which an individual sees or believes in the relationship humanity has with the natural environment

(Kollmuss & Agyeman, 2002:239; Schultz *et al.*, 2005:457) as well as their assumptions about the natural environment itself (Colby & Mundial, 1989:5). Additionally, Miller and Spoolman (2011:661) considers an individual's environmental worldview as the individual's belief regarding what is right and wrong behaviour towards the environment. An individuals' environmental worldview is based on complex knowledge and social beliefs they hold regarding environmental issues and activities (Ogunbode, 2013:1477). The two antipodes of an individuals' environmental worldview spectrum embody either an anthropocentric environmental worldview (human-centred) or a biocentric environmental worldview (earth-centred) (Miller & Spoolman, 2011:661).

An anthropocentric environmental worldview predominantly focuses on humans as the most important species and the particular worldview has no explicit concerns regarding natural resource exhaustion (Colby & Mundial, 1989:8). On the other side of the spectrum, the biocentric environmental worldview considers nature above man (Colby & Mundial, 1989:8) based on ideals and ideas of anti-growth (Dunlap & Van Liere, 2008:19). The biocentric environmental worldview are in line with studying the *ecology in cities* approach (c.f. 2.3.1). The *ecology in cities* approach refers to when human activities are studied as agents of disturbance to ecological conditions (Mcintyre *et al.*, 2000:6; Forman, 2014: 3; McDonnell & MacGregor-Fors, 2016: 936). Nevertheless, the biocentric environmental worldview ideal has many limitations and could according to Colby and Mundial (1989:8) not be a "final goal" to be achieved in development but could rather aid future planning and development projects with important ecological information to become more environmentally friendly (De Geus, 2009:85).

The halfway point for the anthropocentric versus biocentric worldview would be the ecocentric (or life-centred) environmental worldview. The ecocentric environmental worldview recognises that both humans and non-humans are absolutely dependent on the ecosystem processes and accompanied ESs (Washington *et al.*, 2017:35). Colby and Mundial (1989:8) believe that the ecocentric environmental worldview entails that humans recognise that they have an ethical responsibility to the environment through co-development and that they are a "*part of nature, not apart from nature*" (Washington *et al.*, 2017:35). The ecocentric environmental worldview is in line with the cities as urban ecosystems perspective (or studying the *ecology of cities* as urban ecosystems). As was discussed in Chapter 2 (c.f. 2.3.1), the *ecology of cities* approach investigates the co-existence between humans and their influences and needs for ecological processes in urban environments (Cilliers *et al.*, 2014:264). Ultimately, the ecocentric environmental worldview asks; "*how can we (urban planners) create (cities) ecologically?*" (Colby & Mundial, 1989:8) and it could be said that the ecocentric environmental worldview has an applied and holistic outlook and could therefore also be linked with studying cities through the *ecology for cities approach* (c.f. 2.3.1).

Dunlap and Van Liere (2008:19) refer to the above-discussed ecocentric environmental worldview as the “New Environmental Paradigm” (NEP) and on the other hand, the anthropocentric environmental worldview as the anti-ecological Dominant Social Paradigm (DSP). DSP is recognised as the prospects that humans are independent from, and higher valued than other organisms in the natural environment (Hawcroft & Milfont, 2010:143; Ntanos *et al.*, 2019:239) along with characteristics of endless progress and growth (Nooney *et al.*, 2003:764). While on the contrary, the NEP is a shift to recognising a more pro-environmental behaviour (Nooney *et al.*, 2003:764). Pro-environmental behaviour could be defined as possible actions (by humans) that seeks to minimise negative impacts or the safeguarding of the environment (Kollmuss & Agyeman, 2002:239; Balundé *et al.*, 2019:2319).

It has been indicated that pro-environmental behaviour is linked to pro-environmental cognitive components of environmental knowledge and beliefs (Miller & Spoolman, 2011:661). Colding (2011:234) elaborates on “*environmental generational amnesia*”, a case that originates when individuals that are not interacting with the natural environment (ecosystems) causing them to be less interested in supporting necessary environmental awareness or pro-environmental behaviour in society. Predominantly in cities, individuals’ experience of nature is limited and an inadequate supply of and poor-quality green spaces could hinder a pro-environmentalist outlook (Du Toit *et al.*, 2018:257). Both Kollmuss and Agyeman (2002:239) and Félonneau and Becker (2008:25) claim that interaction with the natural environment (ecosystems and green spaces) gives rise to environmental knowledge and environmental awareness and concern that ultimately results in pro-environmental behaviour. Along the same line, Christopher *et al.* (2013:3) believes that more knowledge and awareness regarding ecosystem and their accompanied ecosystem functions and ESs, provoke pro-environmental behaviour and a stronger sense of protection toward natural resources.

Dunlap and Van Liere (2008:19) recognise that it is possible to distinguish between peoples’ anthropocentric (DEP) versus ecocentric environmental worldviews (NEP). In 1978, the authors introduced the *original NEP scale* as an extensive survey-based scale to measure respondents’ environmental worldview (Dunlap, 2008:10; Anderson, 2012:260). However, the original scale soon received critique that the items were “simplistic and outdated” (Dunlap, 2008:11). In 2000, Dunlap and colleagues elaborated on the original NEP scale and revised the scale to address certain weaknesses, shortcomings, and terminologies (Dunlap, 2008:9). Thereafter, the *revised NEP-scale* became widely used in studies as a tool to predict the degree of a human’s pro-environmental behaviour (Moghimehfar, 2016:1; Ntanos *et al.*, 2019:239). The revised NEP-Scale consists of 15 questions where respondents are required to indicate their level of agreement regarding each question on a Likert-scale (e.g., strongly agree, mildly agree, unsure, mildly

disagree or strongly disagree) (Dunlap *et al.*, 2000:433). Eight of the 15 questions are meant to reflect a pro-ecological view (pro-NEP), while the seven other items represent an anti-NEP or the endorsement of the DSP-view (Dunlap *et al.*, 2000:432; Anderson, 2012:260). (The 15-item questions and analysis regarding the NEP-scale are elaborated on in Chapter 7 of the dissertation).

Wilhelm-Rechmann *et al.* (2014:206) conducted a study regarding the environmental worldviews of municipal officials in a South African context by utilising the NEP-scale. Their results claimed a correlation between the environmental worldview of municipal officials' and the inadequate implementation of conservation projects (Wilhelm-Rechmann *et al.*, 2014:206). Pasquini and Enqvist (2019:9) mentioned the same conflict regarding municipal actors' environmental worldview and the implementation of Green Infrastructure in South Africa.

A study by Wallhagen and Magnusson (2017:498) regarding the environmental worldview of urban design professionals in Sweden indicated that urban planners with a more positive ecological view (or pro-environmental perspective) could implement more environmentally friendly approaches in their planning projects. However, their study further indicated a research gap regarding the correlation between the environmental worldview of urban design professionals' (including urban planners) and their decision-making concerning the environment. Environmental worldviews and their influence on the ecological consideration decisions of urban planners in South African context have not yet been investigated. Furthermore, whether environmental worldviews are related to the state of inclusion of ESs in planning practice is also unaddressed. Therefore, this study proposes to investigate this gap in a South African context by means of the empirical investigation through employing the NEP-scale as discussed above (Section B, Chapter 7 of the study).

Nevertheless, an environmental worldview is not the only aspect to consider when studying the state of inclusion of ESs in South African urban planning practice. A general lack of focus on ESs in developing countries has been identified by Cilliers *et al.* (2013), especially in African countries. The following section reflects on ESs in the context of South African urban planning practice.

4.6.3 Ecosystem services and South African urban planning practice

When the study of Du Toit *et al.* (2018:256) investigated research regarding ESs undertaken in sub-Saharan African countries, a clear bias was discovered towards ESs studies in South African urban areas. It was found that provisioning services and regulating services are the most studied ESs categories, while cultural services require more consideration (Du Toit *et al.*, 2018:256). Lindley *et al.* (2018:335) acknowledged a gap in research regarding South African small and medium sized cities. A case-study investigation conducted by Sitas *et al.* (2014:3813)

on local government level (municipality level) in South Africa reported a shortfall regarding the understanding of a variety of ESs among municipal officials. The most prominently identified ESs recognised by the officials were those services essential for human survival (e.g., food, water, and safety) and the services that contribute to the local economy, for instance tourism (Sitas *et al.*, 2014:3813). The empirical evidence of the study of Sitas *et al.* (2014) are in line with the findings of Du Toit *et al.* (2018:256) that African urban planners tend to struggle with poor awareness and lack of knowledge regarding comprehensive ESs.

Schäffler and Swilling (2013:247) suggest moving beyond the assessment of ESs in rural SA, or the effects of ESs delivery elsewhere, to a focus on local-scale ESs. Local-scale ESs studies would refer to specifically investigate those ESs generated from urban green spaces (Colding, 2011:232; Costanza *et al.* 2011:14; Hansen & Pauleit, 2014: 520; Osmond & Pelleri, 2017:34). Accordingly, several authors recommend studying Green infrastructure (GI) elements and the ESs generated from these spaces (Tzoulas *et al.*, 2007; Cilliers & Siebert, 2011; Colding, 2011; O'Farrell *et al.*, 2012:3; Luederitz *et al.*, 2015:108; Steiner, 2016:108).

Hence, a shortage of data, including case-studies on the ESs generated by GI elements (green spaces) result in a lack of evidence to showcase the benefits of implementing GI to generate ESs. A “knowledge-foundation” as mentioned by Niemelä *et al.* (2010) and Mascarenhas (2017:14) is also recommended by local (South African) authors, Schäffler *et al.* (2013:180) and Du Toit *et al.* (2018:256), to provide an evidence base regarding the ESs benefits generated by different GI elements (green spaces). Another author, Kremer *et al.* (2016:29), recommends linking the ESs concept with existing planning concepts such as multi-functionality and green infrastructure planning as an entry point to mainstream the ESs concept, as well as planning for quality green space. Moreover, in relation to the integration of the ESs concept into South African planning approaches, Du Toit *et al.* (2018:256) suggest the improvement of education among decision-makers and Sitas *et al.* (2014:3813) observes opportunities for training regarding ESs.

4.7 Conclusion

The chapter set out to consider the terminologies and interpretations of the ESs concept and to conceptualise ESs in an urban planning context. The chapter has underlined the benefits of ESs and taken together, these findings supplemented urban planning literature on the ESs concept.

The literature investigation confirmed that comprehending terminologies and emphasising the benefits of planning for ESs is a starting point to encourage ESs in urban planning practice. However, also that the incorporation of ESs strongly depends on the importance ESs are provided in urban planning practice. The chapter raised questions regarding urban planners' environmental

worldview and if it could influence the importance, they give ESs in urban planning. These findings then further underlined the importance of studying the views and knowledge of planning practitioners regarding ESs. Hence, research regarding the view, level of awareness and knowledge of among South African urban planners regarding the ESs concept are still unavailable.

In essence, there urge the opportunity to promote ESs in South African urban planning practice and to specifically optimise ESs through urban planning practices. In order to enhance the ESs concept in urban planning practice, the chapter conclude to link the ESs concept with existing planning approach, such as green infrastructure planning and emphasising the concept of “multi-functionality” in urban planning practices. The “multi-functionality” concept however has different meanings and approaches in an urban planning context and are therefore explored in the following chapter.

CHAPTER 5 – CLARIFYING THE MULTI-FUNCTIONALITY CONCEPT WITHIN URBAN PLANNING PRACTICE

5.1 The structure of Chapter 5

Figure 5-1 illustrates the structure of Chapter 5.

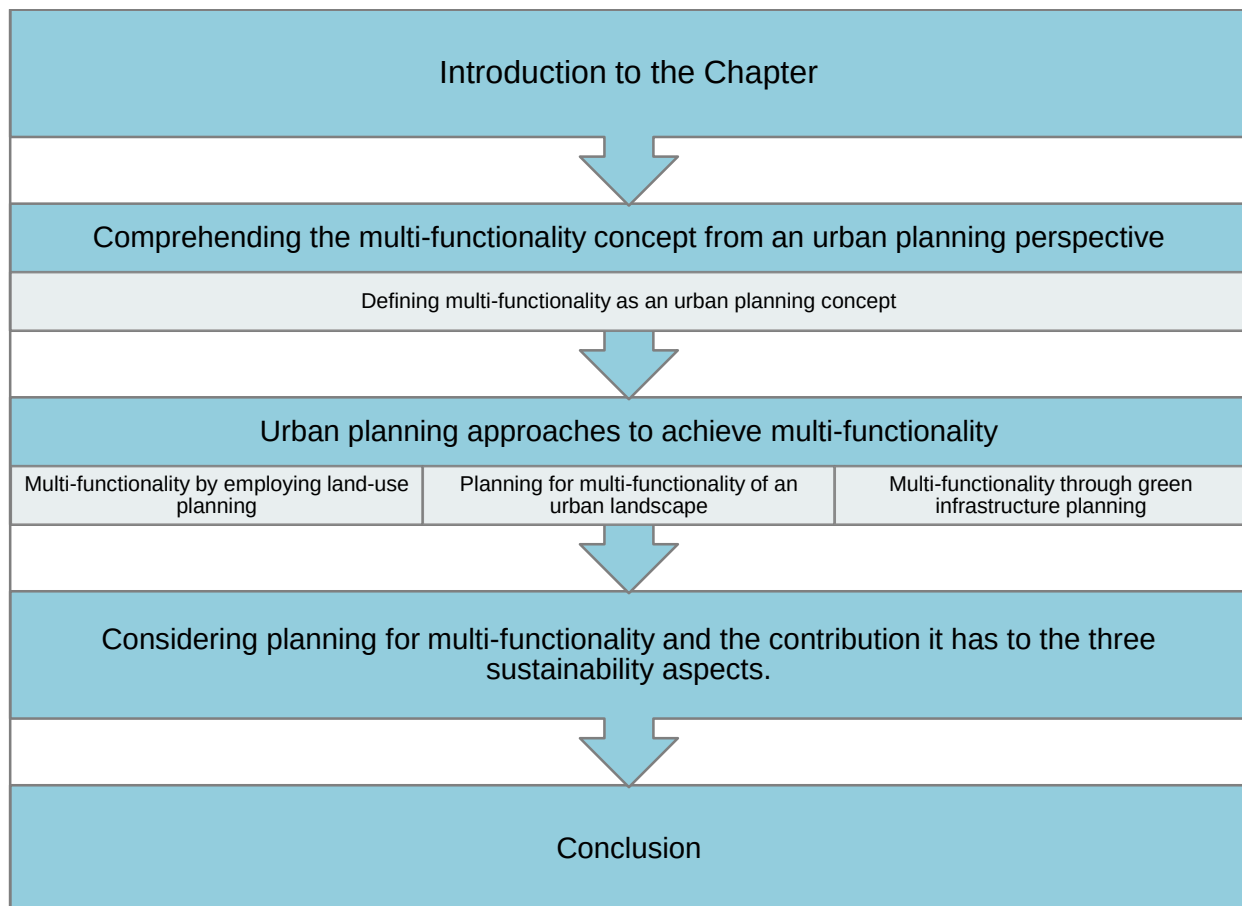


Figure 5-1: The structure of Chapter 5.

Source: Own construction (2020).

5.2 Introduction to the Chapter

According to Molla (2015:90) in urban areas where land is valuable and the challenges are the greatest, quality green spaces are essential. Along the same lines, Mell (2011:58) recognises that the aim of urban planning should be to move away from single use green spaces, to providing more multi-functional spaces that can provide a broader range of benefits for a wider target population (Mell, 2011:58). However, the concept of “multi-functionality” presents different meanings in different disciplines, also in the urban planning discipline (Ghafouri, 2016:10; Hansen *et al.*, 2019:36). Urban planning presents more than one dimension and approach to plan for

multi-functionality. Planners are often more familiar with the approach to plan for multi-functionality by interconnecting and combining several land-uses and their socio-economic functions within the same area (Rodenburg & Nijkamp, 2004:274). The type of multi-functionality that is often overlooked by urban planners is multi-functionality through green infrastructure (GI) planning (Di Marino *et al.*, 2019:644). Hansen *et al.* (2017:43) theorise that there seems to be uncertainty regarding the context and application of the GI multi-functionality principle among planners. The following sections will reflect on the multi-functionality concept, based on dimensions, definitions, and different planning approaches to multi-functionality. For the purpose of this primary research aim (c.f. 1.3), the chapter includes a section with specific focus on achieving multi-functionality through GI planning. Ahern (2011:341) as well as other authors such as Belmeziti *et al.* (2018:2), and Hansen *et al.* (2019:99) emphasise the importance of achieving multi-functionality through GI planning seeing that under the current pressure of urbanisation and urban growth planners will need to find new solutions to plan for quality green spaces that generate sufficient ecosystem services (ESS) in increasingly limited urban space.

5.3 Comprehending the multi-functionality concept from an urban planning perspective

According to both Viviers (2018:15) and Živković *et al.* (2019:206) the idea of planning for multi-functionality is not a new notion. The application of multi-functionality gained popularity from the agricultural research field (Hansen *et al.*, 2019:13). Holmes (2006:142) perceived multi-functionality in the context of agriculture as related to redeveloping from mono-functional food production, to the “joint production” between agricultural, forestry, and other land-uses (Selman, 2009: 46; Wei, 2017:16). The concept has since been methodically and theoretically developed by several other disciplines and new ideas and practices regarding multi-functionality contributed to the development of different multi-functionality concepts (Viviers, 2018:15). In urban planning practice, the multi-functionality concept has been employed in projects and plans towards promoting more sustainable cities (Wei, 2017:4). When planning for multi-functionality Živković *et al.* (2019:206) recognise four dimensions. **Table 5-1** illustrates the four dimensions as multi-functionality through *space* (spatial coverage), multi-functionality through *usage*, *time*, and multi-functionality based on the *services* provided by the space.

Table 5-1: Dimensions regarding multi-functionality.

DIMENSION	DESCRIPTION
<i>Space</i>	Based on the horizontal or vertical interconnection of different functions within a space or area, depending on the spatial scale.
<i>Usage</i>	Refers to planning for the feature of a space to provide several functions for humans and other living beings to use the space for different activities or opportunities.

DIMENSION	DESCRIPTION
<i>Time</i>	Based on the ability of a space to provide different functions in the same spaces but have time difference shifting the roles of the space at different times (e.g., sequentially over the day).
<i>Services</i>	Based on the capability and value of a space to deliver multiple services.

Source: Own construction based on Wei (2017) and Živković *et al.* (2019).

According to Živković *et al.* (2019:206) the different dimensions, as discussed in **Table 5-1**, contribute to an on-going debate regarding the implementation of the multi-functionality concept in urban planning practice. Moreover, according to Wei (2017:3) several definitions in urban planning practice have developed related to the multi-functionality concept.

5.3.1 Defining multi-functionality as an urban planning concept

Multi-functionality is understood as a broader concept to the holistic approach of combining economic, ecological, and social objectives within an area (van Broekhoven *et al.*, 2015:1005). According to Hansen *et al.* (2019:36) studying multi-functionality in an urban planning context, it is most relevant to study multi-functionality as urban land-use concept, the concept of multi-functionality in an urban landscape, and multi-functionality as the GI planning principle.

Urban planners introduced the concept of multi-functionality as land-use concept to describe the “*combination of different socio-economic functions within the same area*” (Ghafouri, 2016:20). In the same line, Živković *et al.* (2019:206) recognises multi-functionality as land-use concept as to focus on the “*space*” dimension (c.f. **Table 5-1**). Accordingly, the concept is defined by Batty *et al.* (2004:325) as the possibility of having more than one land-use and activity or function within the same urban space.

While multi-functionality as an urban land-use concept focuses on a land-use at spatial scale, the urban landscape multi-functionality concept has a broader scale (e.g., a neighbourhood or a city level-scale) and addresses an urban landscape (Selman, 2009:46). Hölting *et al.* (2019:1) claim that multi-functionality in terms of an urban landscape is generally understood as the combination of several functions, including different socio-economic benefits provided by a variety of land-uses within an urban landscape (Ghafouri, 2016:36) or considering multiple natural and built (infrastructure) space as a whole (Živković *et al.*, 2019:206). Hölting *et al.* (2019:1) furthermore describes a multi-functional urban landscape as a “multifunctional hotspot” where several spaces within the same landscape contribute to multi-functionality in collaboration. Multi-functionality of an urban landscape also has the ability to provide a variety of ecosystem goods and services and could therefore meet in a variety of social needs (Hansen, 2018:29; Živković *et al.*, 2019:206).

Both Charoenkit & Piyathamrongchai (2019:1) and Živković *et al.* (2019:206) observed that the focus of the multi-functionality concept has recently drawn attention to GI planning. As previously discussed in Chapter 2 (c.f. 2.4.2.1) multi-functionality is considered as one of the core spatial planning principles underlining GI planning. Multi-functionality as a GI principle includes the intertwined or combination of different functions within a GI element that enhance the delivery of multiple environmental, economic, and social benefits (Pauleit *et al.*, 2011; Lennon *et al.*, 2016; Hansen *et al.*, 2017). Accordingly, multi-functional GI elements are considered by Lovell and Taylor (2013:1147) as green spaces that simultaneously support human and social aspects, providing functions and services to urban dwellers, likewise securing ecological processes by providing habitable spaces for a variety of plant and animal species. In general, Hansen *et al.* (2019:100) describes multi-functionality in terms of GI as the capacity of GI elements to provide multiple ecosystem services. Davies *et al.* (2006) stress that planners require a conceptual understanding, as well as knowledge pertaining the multi-functionality GI principle.

However, different definitions regarding the multi-functionality concept led to different practical interpretations and approaches. Further consideration regarding how the different multi-functionality concepts are implemented as approaches in urban planning practice follows in more detail.

5.4 Urban planning approaches to achieve multi-functionality.

This section further draws on Hansen *et al.*'s (2019:36) conceptualisation of multi-functionality in an urban planning context as 1) multi-functionality by employing land-use planning, 2) Planning for multi-functionality of a landscape, and 3) Multi-functionality through GI planning. The following section will reflect on all three above-mentioned approaches. The first two approaches are discussed for urban planners to comprehend the different approaches to achieve multi-functionality through urban planning practice. The largest part of the section will primarily draw on the third mentioned approach, namely the multi-functionality through the GI planning approach.

5.4.1 Multi-functionality by employing land-use planning.

Conventional urban planning practice considers a mono-functional approach when planning for land-uses, thus, resembling the planning of uses such as recreational, residential, employment and nature in separate urban spaces (van Broekhoven *et al.*, 2015:1005). However, the before mentioned involves “functional-segregation” of land-uses that contributes to problems of spatial fragmentation, social segregation, and high levels of urban sprawl (Živković *et al.*, 2019:206). As opposed to that, van Broekhoven *et al.* (2015:1005) claims more recently multi-functional spaces have received more attention in land-use planning. The primary purpose of planning for multi-functionality by means of land-use planning is to deal with the spatial component or the “space”

dimension of multi-functionality (c.f. **Table 5-1**) that considers horizontal or vertical interconnection of functions within a space (Vreeker, 2004:1; Živković *et al.*, 2019:206). **Figure 5-2** illustrates an example of multi-functionality based on horizontal or vertical interconnection of functions within an urban space.



Figure 5-2: Illustration of horizontal and vertical interconnection of a multi-functional space.
Source: Adapted from Placemakers.com (2013).

A multi-functional space as illustrated in **Figure 5-2**, aims to achieve a synergy between multiple socio-economic functions and support more than one activity within a space (Živković *et al.*, 2019:208) in order to meet different social demands (Selman, 2009:45).

The multi-functional as a land-use concept is associated in urban planning literature with high density development and are similar to approaches such as the “Compact city” (designing cities to have high density), “smart growth” (concentrating growth in high density, walkable, bicycle-friendly areas) or “mixed land-use development” (combining a combination of uses, e.g. residential, commercial, cultural, recreational or working activities within the same space - as illustrated in **Figure 5-3**) (Vreeker, 2004:1; van Broekhoven & Vernay, 2018:1875; Živković *et al.*, 2019:208; Zhu *et al.*, 2020:1615).

Planning for multi-functionality through land-use planning aids planners to deal with the scarcity of land availability in urban areas, as well as controlling urban sprawl (Vreeker, 2004:1; Ghafouri, 2016:36; Hansen, 2018:55). It is further assumed that multi-functional land-uses are related to sustainable development, benefiting social cohesion, and creating livelier, attractive, and safer urban spaces (Hansen *et al.*, 2019:13).

5.4.2 Planning for multi-functionality of an urban landscape

Forman (1995:134) defines a landscape as “a mosaic of urban land compromising of variety of ecosystems and land-uses that are arranged according to ‘landscape elements’ of patches,

corridors, and a matrix". Urban landscapes are often characterised as highly heterogenic (Andersson *et al.*, 2014:445) and compose of the following urban landscape elements (Ahern, 2007:271):

- **Patches**, for example parks, sport fields, wetlands, community and domestic gardens, cemeteries, vacant lots, and other green open spaces.
- **Corridors**, for example rivers, canals, drainage ways, roads, and power lines.
- **Matrix**, that represents the dominant land cover of an area, for example, residential neighbourhoods, industrial districts, commercial areas, or mixed used districts.

Rode (2016:326) considers these above-mentioned landscape elements predominantly as mono-functional elements (separated patches, corridors, and matrix) designed and managed to each serve one particular function (Pauleit *et al.*, 2011:273). Moreover, these mono-functional landscape elements are separated from one another to a great deal in districted zones of different land-uses within an urban landscape (Rode, 2016:326). The landscape multi-functionality concept in urban planning would propose the spatial arrangement and concentration of these mono-functional landscape elements within an individual urban landscape (Hansen *et al.*, 2019:17). Considering the *space* dimension of multi-functionality (c.f. Table 5-1) horizontal interconnection of different landscape elements and their function within an area could be perceived together as landscape multi-functionality (Živković *et al.*, 2019:206). In line with this, Rode (2016:328) suggests three landscape multi-functionality types of urban planners could plan for (see **Figure 5-3**):

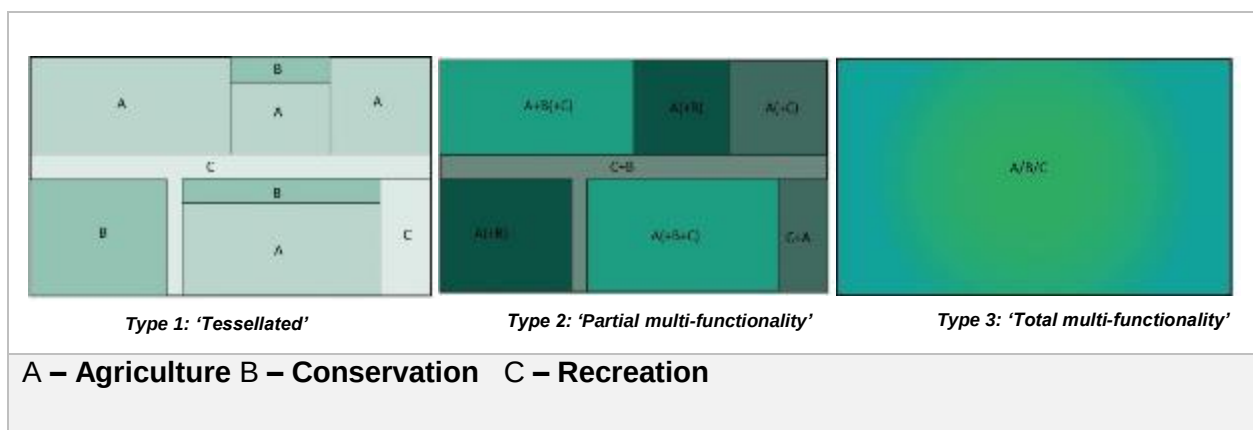


Figure 5-3: Types of multi-functionality in landscapes.

Source: Adapted from Hansen (2018).

- 1) *"Tessellated multi-functionality"* suggests the spatial separation of different landscape elements and their functions. For instance, the separation of agricultural, conservation, and recreational land-uses from one another, however these land-uses are still in close proximity and integrated within the same urban landscape. According to Hansen

(2018:17) tessellated multi-functionality represents the pattern of a typical mono-functional urban landscape (Hansen, 2018:17).

- 2) “*Partial multi-functionality*” includes the combination of two or more landscape elements within the same landscape, however one of the landscape elements still dominates the land-use. For example, when studying **Figure 5-3**, Type 2, a partial multi-functionality approach would combine **A – agriculture** with **B - conservation**, but the agriculture (**A**) land-use is still the dominant land-use within the particular landscape.
- 3) “*Total multi-functionality*” suggests the equal integration of the different landscape elements and their functions within an urban landscape. As seen in **Figure 5-3**, this approach would include for example the planning for a balance between **A - agricultural**, **B - conservation**, and **C – recreation** land-use within the same landscape.

When Wei (2017:17) studied multi-functionality, it was found that research is prone to focus predominantly on landscape multi-functionality, while local level and everyday use spaces such as the GI elements, are the least considered in research on multi-functionality (Daniels *et al.*, 2018:1365).

5.4.3 Multi-functionality through GI planning

The green infrastructure (GI) planning concept as an approach to plan for multi-functionality differs from the traditional idea of multifunctional urban landscape planning in the sense that it has a stronger emphasis on the idea of generating ESs for a quality urban environment (Wei, 2017; Hansen *et al.*, 2019:100). According to Hansen (2018:1) the multi-functionality principle of GI planning and the ESs concept have both been taken up in urban planning practice and research, however the connection between the two concepts is not yet widely understood. In order to connect the concepts of multi-functionality and ESs, as well as to contextualise them in urban planning practice, Lennon, and Scott (2014a) suggest the three Ps’ framework of *principle, practice, and procedures* as a useful approach. The “*principles*” reflect on the purpose and what GI planning seeks to achieve, “*practice*” covers the replicability of the principle based on empirical and existing realities, and “*procedures*” includes theoretical models, skills set, planning process and decision-making considerations required to achieve the *principles* and *practice* (Hebbert, 2009:359; Lennon & Scott, 2014a:8). A discussion on the “three P’s” (*principles, practice, and procedures*) related to GI multi-functionality follows.

5.4.3.1 The **PRINCIPLE** of GI multi-functionality

In a previous section of this dissertation (section 2.4.2.1) the underlining spatial principles of GI planning as “connectivity and networks”, “integration” (of people, places, and policies), “social inclusion”, “long-term strategies”, and the principle of “multi-functionality” were discussed (Davies

et al., 2006:14). Multi-functionality, along with the connectivity principle, has according to literature become one of the core principles of GI planning (Mell, 2010:58; Mell, 2011:58; Hansen & Pauleit, 2014: 525; Lennon & Scott, 2014a:16; Wei, 2017:10).

The GI planning principle of multi-functionality suggests a holistic approach that seeks a synergy between multiple ecological, social, and economic functions concurrently within green spaces (Hansen & Pauleit, 2014: 525; Davies *et al.*, 2015:14). The principle of multi-functionality could according to the Town and Country Planning Association (2007:19) also be expressed in the combination of green resources with other forms of urban infrastructure to fulfil many of the functions of traditional physical grey infrastructures (Konijnendijk *et al.*, 2004:99). Selman (2002:293) agrees with this perspective of multi-functionality and stresses the importance for planners to consider the principle of multi-functionality as a strategy to ensure interactive and quality green spaces that consequently enhance resilience, environmental health, and human well-being (Mell, 2010:58).

Seeing that the GI planning approach and the core principle of multi-functionality has the potential to adopt ecological knowledge in urban planning practice by integrating both ecology and planning principles (Pauleit *et al.*, 2017:47) the principle of multi-functionality has become an important part of spatial planning (Selman, 2009:45). Hansen (2016:54) claims the multi-functionality principle is an “aim” to be achieved by urban planning. The ways and means on how planners could achieve multi-functionality in urban planning practice through the GI planning approach are explained through the two other P’s of the framework, namely, *practice* and *procedures*.

5.4.3.2 The **PRACTICE** of planning for the GI multi-functionality principle

It has been stressed that urban planners need to find approaches to fulfil more than one purpose in a singular space, to provide ESs in increasing limited space (Ahern, 2010:146; Colding, 2011). Hansen (2018:55) claims there is a conceptual linkage between planning for multi-functional spaces and ESs. Conventional urban planning approaches consider a mono-functional approach when planning for green spaces (van Broekhoven *et al.*, 2014:1005). Consequently, as seen in **Figure 5-4**, these spaces are separated and “one-dimensional” (Schäffler & Swilling, 2013:247) solely providing individual benefits or a single ESs category instead of providing multiple critical ESs (Czembrowski *et al.*, 2019:3).

On the other side of the spectrum (**Figure 5-4**), the GI planning approach is a resourceful and effective way to promote multi-functionality (Madureira & Andresen, 2014:39) and to integrate multiple ESs into urban planning (Molla, 2015:90).

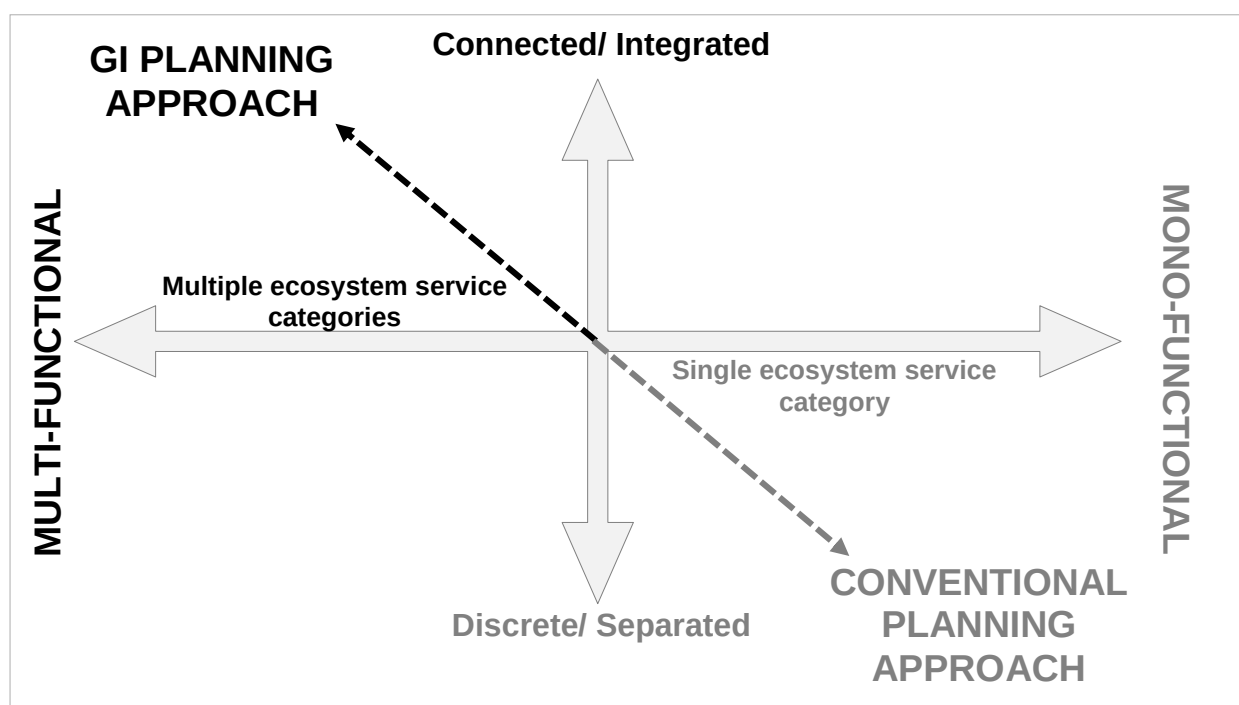


Figure 5-4: Conventional planning approach vs achieving multi-functionality through the GI planning approach.

Source: Own construction based on Lennon and Scott (2014a).

Hölting *et al.* (2019:226) and Kim and Song (2019:3917) theorised on ESs and its interconnection with multi-functionality, stating that in contrast to planning green spaces according to conventional planning approaches (**Figure 5-4**) that only supply one ES category, the GI planning approach (**Figure 5-4**) has the ability to provide several functions and a variety of ESs categories at the same time (Pauleit *et al.*, 2011:274). The study of Hansen *et al.* (2016:54) argues that planning for multi-functionality aims to achieve the target of planning for optimised quality green spaces, as well as to follow a *protective* (employing preventative actions to preserve existing GI elements) and *defensive* (measures to defend GI elements) approach to secure those green spaces that are already of high multi-functionality (c.f. Table 2-3- Ahern, 2007). On the other hand, Ahern (2011:4) proposes multi-functionality in the case of GI could be accomplished through either planning for the combining, stacking, or time-shifting of functions. In the same line, Iojă *et al.* (2014:705) claims multi-functionality of GI could occur through alternative (time-shifting) or simultaneous (combining or stacking) scheduling. **Table 5-2** provides a discussion on the strategies of combining functions, stacking or time-shifting functions to achieve multi-functionality, as well as examples of the implementation of these strategies.

Table 5-2: Achieving multi-functionality through planning for combining, stacking, or time-shifting of functions.

STRATEGY	DESCRIPTION	EXAMPLE
Combining functions	The simultaneous spatial integration of functions in a space to provide multiple ESs and conjointly benefit the local economy,	Sport fields, such as a football fields mainly present a recreational function but also have regulating functions such as storm water

STRATEGY	DESCRIPTION	EXAMPLE
	environment health, and social needs (Selman, 2009:47).	infiltration and mitigating the urban heat island (UHI) effect; and providing aesthetic benefits by softening the hard urban grey infrastructure.
Stacking	Seeking to vertically “stack” multiple functions in one location to exploit synergies between functions and simultaneously support social needs, environmental health, and economic vitality through construction multi-layer constellations (Rodenburg, 2004:274; Selman, 2009:47; van Broekhoven & Vernay, 2018:1875).	A multifunctional crossing for wildlife over or under roads; green roofs on office buildings and green walls; and water infiltration systems underneath parking areas.
Time-shifting	Also referred to as “real-time scheduling”. The employment of differentiation and coordination of ESs or functions in the same space, but with time difference shifting the roles of the space at different times of the day or of a year (Rodenburg, 2004:274; Ahern, 2010:147)	Restrict recreational use of habitat during breeding seasons of some animal species (e.g., frogs, birds); less use of hydrological systems during high flow periods (e.g., parks located near floodplains), or by closing certain roads at night for the movement of nocturnal animals (e.g., frogs or aardvarks).

Source: Own construction based on Rodenburg (2004); Selman (2009); Ahern (2010); Cilliers and Cilliers (2016); van Broekhoven and Vernay (2018).

The strategies in **Table 5-2** could be applied to a small single site (GI element) or between connected GI elements (Ioja *et al.*, 2014:705; Hansen *et al.*, 2017). Multi-functionality should be seen as the desired planning outcome, (Lovell, 2010:2520) broadening the conventional planning perspective from planning solely for a single ES to a concentration on multi-functional green space provision (Anderson *et al.*, 2016:446).

Several authors recognise ESs to operationalise multi-functionality (Willemsen *et al.*, 2010:62; Mejía *et al.*, 2015:530; Lindley *et al.*, 2018:330). Hölting *et al.* (2019:124083) however, stress that it is important to bear in mind that multi-functionality is not solely “the more ESs the better”, but it rather depends on the numerous ESs categories (provisional, cultural, regulating, and supporting services) recognised within the multi-functional space.

Incumbent on the multi-functionality principle to contribute to optimal ESs, invokes a meaningful link between ESs and GI (Lindley *et al.*, 2018:330). GI elements are granted as fundamental urban infrastructure (Lennon & Scott, 2014b:3) to deliver ESs (Everard, 2009:5; Lennon & Scott, 2014a:22). The literature therefore emphasises the enhancement of GI planning in mainstream urban planning practices (Hansen, 2018:29). According to Lovell and Taylor (2013) for multi-functionality to be realised in the long-run, data needs to be gathered that will convince decision-makers of the results of the GI planning approach to advance multi-functionality and deliver ESs that contribute to quality green space, quality of life and quality urban environments (Mell, 2011:58). Hansen *et al.* (2017:34) state that to enhance the significance of GI to advance multi-

functionality, the ESs generated from GI elements must be emphasised and compiled into a “multi-functionality inventory” that could aid decision-making and green space provisioning plans.

5.4.3.3 The **PROCEDURES** to consider for the multi-functionality principle.

Lennon & Scott (2014a:18) mentions the importance of considering producers related to the GI planning approach that requires the effectiveness of the above-mentioned “practice” of planning for the multi-functionality principle. Such “*procedures*” are identified in the literature concerning the countering of the “silo thinking” of urban planning practice (Lennon *et al.*, 2016:850; Hansen *et al.*, 2017) considering a “pro-active” approach to planning (Lennon & Scott, 2014a:18; Hansen *et al.*, 2017:43) along with “learning-by-doing” actions (Ahern *et al.*, 2014:255; Hansen *et al.*, 2017:66), and the re-scoping of the outlook of urban planning practice (Tan, 2017:18).

The re-scoping of urban planning practice entails becoming more “ecological” in planning decision-making and processes (Tan, 2017:18). To incorporate ecological knowledge and new approaches that are not yet necessarily considered as a priority in mainstream urban planning practice (Ahern *et al.*, 2014:255). Moreover, the ideas of planning becoming more ecological requires cross-sectoral and cross-departmental cooperation within planning practice to integrate knowledge and expertise from different professions (Hansen *et al.*, 2017:66). However, conventional urban planning practice tends to be top-down, planning for, managing, and building cities in distinct entities where planning approaches are often dealt with in separate academic, administrative and implementation “silo’s” (Osmond & Pelleri, 2017:32).

A GI planning approach to achieve multi-functionality requires overcoming the “silo mentality” (Lennon *et al.*, 2016:850) aiming towards incorporating a transdisciplinary and cross-organisational team within urban planning practice (Town and Country Planning Association, 2007:8; Selman, 2009:50; Wright, 2011, 1011; Lennon & Scott, 2014a:21). Hence, bringing about a successful strategy, involves the building of common ground for multiple disciplines (e.g. urban planners, engineers, landscape architects, ecologists) and other departments (e.g. current local governance authorities and planning structures) in collaboration with non-governmental stakeholders (e.g. public and private landowners, voluntary organisations, as well as individuals and communities) and means towards applying the multi-functionality principle (Town and Country Planning Association, 2007:8; Selman, 2009:50; Mell, 2010:39; Pauleit *et al.*, 2011:257; Ahern *et al.*, 2014; Lennon *et al.*, 2016:850; Wei, 2017:19).

Lennon & Scott (2014a:18) and Hansen *et al.* (2017:43) furthermore state that rather than the traditional “preserve and protect” conservation approaches, planning for multi-functionality is likely to need of a more “proactive approach”. A proactive approach mirrors the “offensive” strategy

(discussed in Table 2-3) proposed by Ahern (2007) as taking remedial or restorative actions to plan for GI elements and functions under development pressure. According to Hansen *et al.* (2017:66) an example of a proactive approach would be to develop a framework that indicates functions and ESs provided by GI elements and to identify areas where multi-functionality requires further enhancement. As means to the proactive approach is a “learning-by-doing” process or in other words that GI should be planned before development (Benedict and McMahon, 2006:41). Ahern *et al.* (2014:255) recommended a “safe-to-fail” design to help planning professionals with the practice of learning-by-doing. Safe-to-fail design is based on a transdisciplinary scientific approach to experiment, adjust, and refine GI planning plans and strategies before it is implemented in other areas (Ahern *et al.*, 2014:255; Hansen *et al.*, 2017:66).

5.5 Considering planning for multi-functionality and the contribution it has to the three sustainability aspects.

Selman (2009:46) and Kato and Ahern (2009:799) recognise that the strength of multi-functionality lies within the potential of a space to serve more than one function and thus fulfilling in several needs. Ahern (2007:257), as well as Živković *et al.* (2019:206) furthermore recognised these multiple functions in one space as an important strategy for urban sustainability. The basis for linking multi-functionality and sustainability occurs where these multi-functional spaces provide ecological, social, and economic functions for the needs of the current and future generations (Mell, 2010:19). Mejía *et al.* (2015:530) confirm that GI elements presents the potential to contribute to all three aspects of sustainability – environmental, social, and economic. **Table 5-3** highlights the benefits of multi-functionality in relation to the three aspects of sustainability.

Table 5-3: The benefits of multi-functionality in relation to the aspects of sustainability.

ASPECTS OF SUSTAINABILITY	BENEFITS OF MULTI-FUNCTIONALITY
<i>Environmental aspect</i>	• The bio-physical characteristics of the space provide increased ecological functions (e.g., protecting ecosystems, representing natural habitats and life-support system for humans by generating multiple ES, c.f. Chapter 4). • Contributes to the appreciation and protection of natural remnants in urban areas.

ASPECTS OF SUSTAINABILITY	BENEFITS OF MULTI-FUNCTIONALITY
<i>Social aspect</i>	• Diversification and variety of combined activities in a space attracts more people to the space. • Increase of possible activities that further enhance positive usage of a space by different user groups. • Benefiting social cohesion with different levels of social interaction. • Creating more lively, attractive, and safer identity to an area (better quality living spaces). • Enhance identity and sense of place of an area. • Contributing to human health and well-being as indicated by the MA (2005) in Figure 4-2, for instance, to experience recreational and aesthetic values.
<i>Economic aspect</i>	• Stimulate local economic activities and growth. • Enhance attractiveness attracting tourism and new inhabitants. • More inward investment provides for the generation of new recreation and leisure opportunities. • Raises local land and property values. • Positive impact on workforce, with benefits for productivity. • Meet multiple municipal public services (e.g., combined water, waste, and storm water management).

Source: Own construction based on Douglas and Ravetz (2011:252); Schäffler *et al.* (2013:12); Mejía *et al.*, (2015:530); Molla (2015:93); Konijnendijk *et al.* (2006); Hansen *et al.* (2019:13); Živković *et al.* (2019).

The benefits discussed above (**Table 5-3**) could also refer be linked to the different ESs categories (c.f. 4.4) that meet ecological, economic, and social needs of urban areas (Cilliers & Cilliers, 2016; Mell, 2011:17). The benefits diverted form multi-functional spaces would, however, require further exploration seeing that multi-functionality depends on context-specific considerations regarding the provision capacity of different GI elements (Hansen, 2016:54).

The broad range of benefits and opportunities multi-functionality provides actively encourages people to use green spaces (Konijnendijk *et al.*, 2006). Ultimately, Pauleit *et al.* (2011:273) and Mell (2010:25) claim that multi-functionality strengthens the role of green spaces in urban areas. Planning for multi-functionality ensures that green spaces are of a certain quality (Hansen *et al.*, 2016:54), changing the false perception that they are “a luxury good” to a perspective that they are spaces that meet urban demands, merit to the same priority as other infrastructures in urban areas (Cilliers, 2019a:455).

5.6 Conclusion

This chapter set out to reflect on the multi-functionality concept within an urban planning context, as well as urban planning approaches to plan for multi-functionality. The second aim was to

investigate planning for multi-functionality as meaningful link between green infrastructure (GI) and ecosystem services (ESs).

Previous studies investigated multi-functionality in an urban planning context and observed that multi-functionality could be assessed and planned for at different spatial scales, along with different dimensions. Based on the literature investigation, the chapter presents three multi-functionality concepts applicable in an urban planning context.

Figure 5-5 summarises the different concepts for urban planners to consider under multi-functionality, as well as planning strategies to plan for the different concepts of multi-functionality.

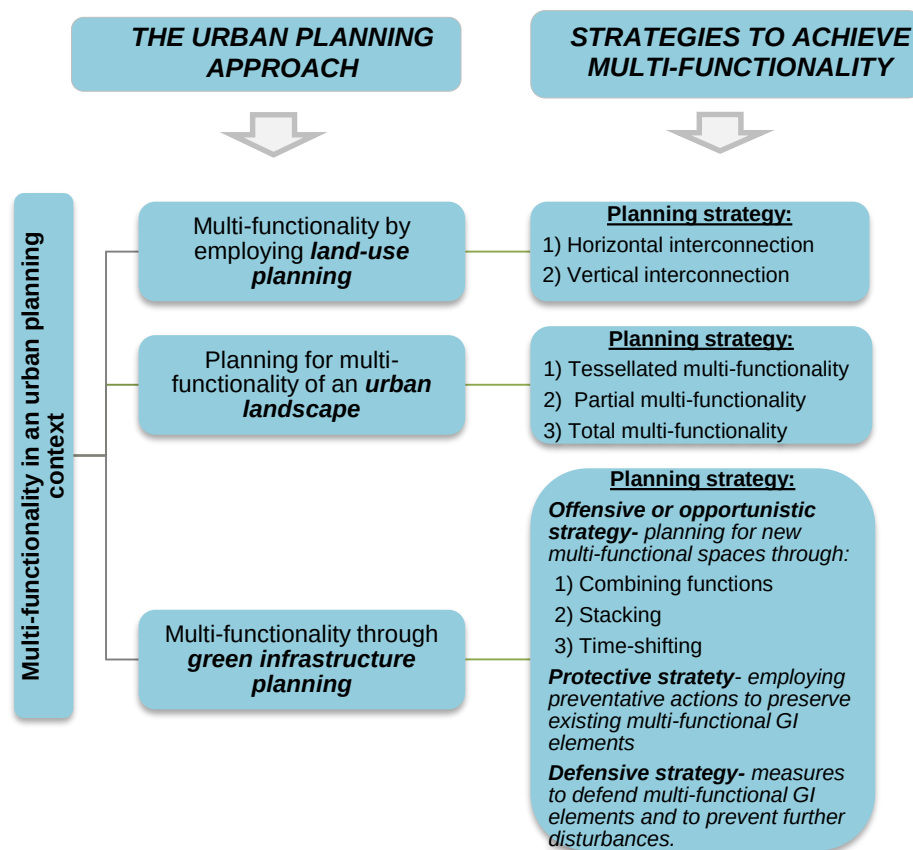


Figure 5-5: Multi-functionality within an urban planning context.

Source: Own construction based on section 5.4.

The chapter contributes to urban planners understanding of the concept of multi-functionality. Although multi-functionality has become a desired planning aim or outcome, the literature indicated that planners are generally less familiar with the approach to plan for multi-functionality through the GI planning approach. The focus on achieving multi-functionality through a GI planning approach supports the idea of integrating both ecology and planning principles in green

space planning and provision. It is through the GI planning approach that a strong relationship between multi-functionality and ESs has been reported in the literature. Taken together, the findings of the chapter emphasise the role of GI in advancing multi-functionality and providing several ESs. Planners therefore need to be made aware of and be able to implement GI to this effect. These findings have further implications for the understanding of the capability of GI elements to generate ESs and the multi-functionality of different GI elements. In the light of this (and to address the primary research aim), the remaining focus of the research falls on investigating GI elements (as identified in Chapter 3, Table 3-3) and the ESs (as identified in Chapter 4, Table 4-2) generated by these elements to ultimately assess the multi-functionality of different GI elements.

SECTION B: EMPIRICAL INVESTIGATION

The empirical investigation for the dissertation employed a mixed-method research approach. A mixed-method research approach incorporates elements of both qualitative and quantitative approaches, allowing for a more comprehensive understanding of a research problem or phenomenon (De Vos *et al.*, 2011:66). Many research designs exist in the mixed-method approach (Creswell, 2014:43). The chosen research design for this dissertation is an *embedded research design*. An embedded research design involves a larger design (either qualitative or quantitative) along with the idea to support the design by nesting qualitative or quantitative data within the large design (Creswell, 2014:44). **Figure B1** illustrates the embedded research design for this dissertation.

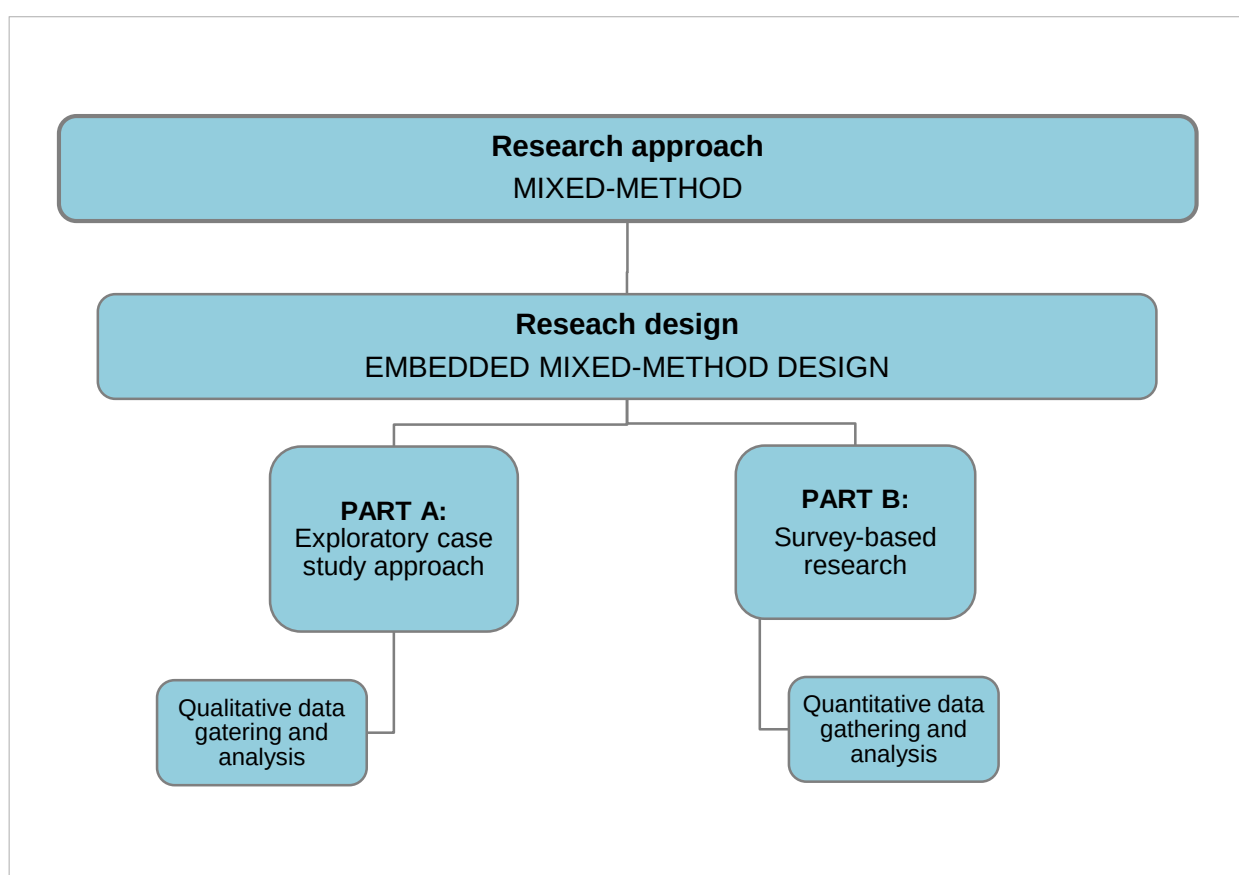


Figure B1: The research approach for the empirical investigation of the dissertation.

Source: Own construction.

Figure B1 indicates that the embedded research design for the dissertation includes the following research design components:

PART A: A qualitative exploratory case-study approach as the employed research strategy. The first phase of research design is to qualitatively explore the ecosystem services (ESs) generated by South African best practice examples showcasing green infrastructure (GI) elements. From

this initial exploration, the qualitative findings are then utilised in section 6.5 as means to determine the multi-functionality of the GI elements. More detail on the research methods (data collection and analysis) will follow in Chapter 6. The mixed-method research approach thereafter aimed to further investigate the phenomena (ecological aspects and concepts of ecosystem services, green infrastructure elements and multi-functionality) by means of survey-based research.

PART B of the embedded mixed method approach gathers quantitative data through survey-based research. The survey-based research is employed to reach a better understanding of South African urban planning practice regarding 1) the ecological aspects and concepts of GI planning, ESs, and multi-functionality among South African planners, 2) the current state of integration and implementation of such ecological considerations in South African urban planning practice. More detail on the research methods (data collection and analysis) follows in Chapter 7.

Accordingly, the structure of the empirical investigation features the following two chapters:

Chapter 6 – An exploratory case-study approach to clarify the connection between ecological considerations: Part A - qualitative investigation of the exploratory case-study approach.

Chapter 7 – Gathering empirical evidence on South African urban planners' knowledge and considerations to ecological aspects and concepts: Part B – quantitative investigation using a survey-based research approach.

CHAPTER 6 – AN EXPLORATORY CASE-STUDY APPROACH TO CLARIFY THE CONNECTION BETWEEN ECOLOGICAL CONSIDERATIONS

6.1 The structure of Chapter 6

Figure 6-1 illustrates the structure for Chapter 6.

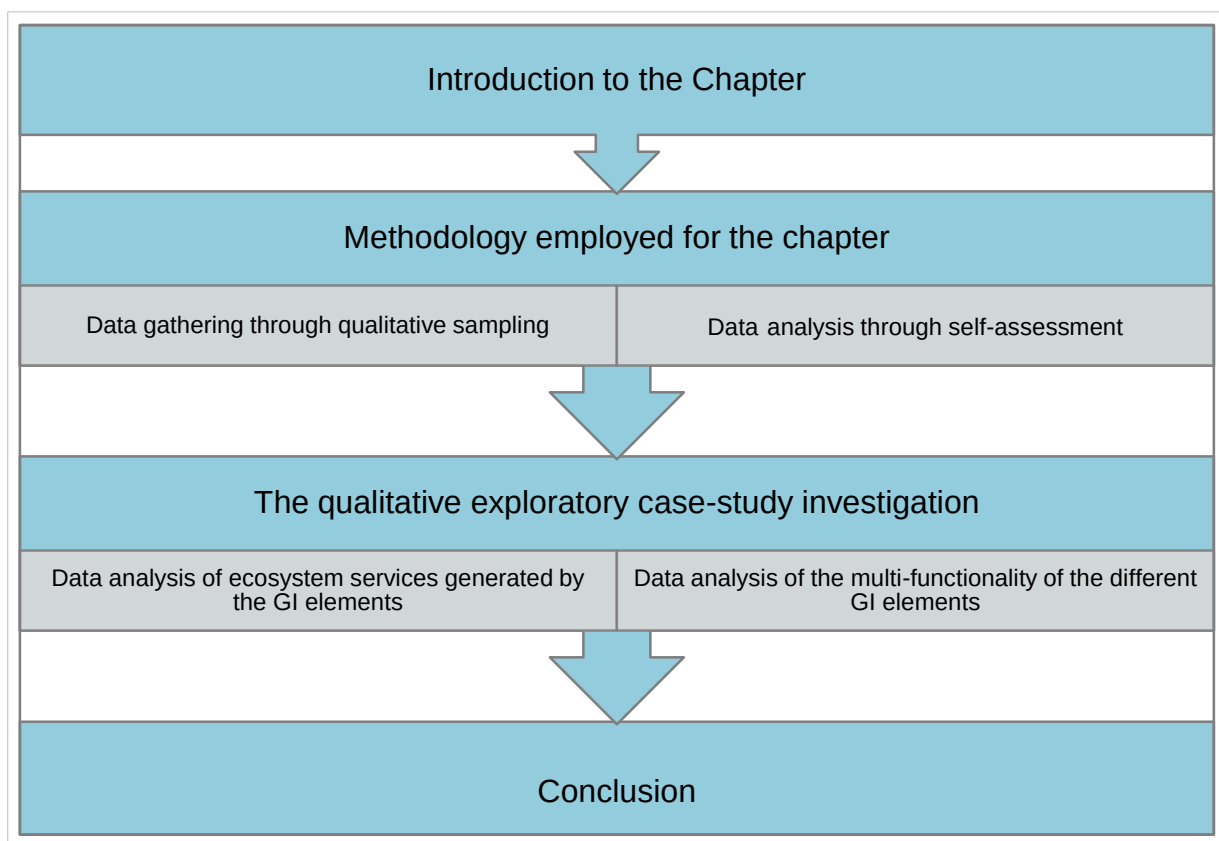


Figure 6-1: Structure for Chapter 6.

Source: Own construction (2020).

6.2 Introduction to the Chapter

An opportunity for the exploration of the capacity of different Green Infrastructure (GI) elements to provide ecosystem services (ESs) was identified from the previous literature investigation (c.f. **5.6**). Determining the multi-functionality of elements depends on the capability of each element to provide ESs (Hansen *et al.*, 2016). Du Toit *et al.* (2018:258) suggests the local and context-based (African context) assessment of GI and its associated ESs. Therefore, the aim of this chapter is to investigate best practice examples of GI elements in a South African context (identified in the inventory c.f. **Table 3-3**) and to assess the ESs generated by these GI elements. Moreover, the importance of multi-functionality as a principle of GI, is still unknown and undervalued in the local South African context (Cilliers, 2019a:455). Therefore, the empirical investigation further aims to

determine whichever GI elements advance multi-functionality. Ultimately, the results of the investigation are utilised to provide South African urban planning practice with a framework comprised of examples of South African GI elements and the ESs generated by these elements, along with the level of multi-functionality of the elements. The results would be further utilised to conclude on the connection between the ecological aspects and concepts of GI planning, ESs and multi-functionality.

The first section of Chapter 6 introduces the methodology employed for the exploratory case-study approach and thereafter elaborates on the research methods (data gathering and analysis) employed. The data gathered and analysed are presented respectively in section 6.3 and section 6.5.

6.3 Methodology employed for empirical investigation: PART A

A case-study approach is frequently used in urban planning research (Maccallum *et al.*, 2019:45). Similar to other research fields, variations regarding the “case-study” concept are found in planning literature (Farthing, 2016:201). For the purpose of this dissertation, the study agrees with the understanding of Creswell (2014:44) whereas a case-study approach is considered as a research strategy that focuses on understanding contemporary phenomena within a real-life context (Shareia, 2016:3840). An important feature of the case-study approach is the contribution it has to practically orientated disciplines (Starman, 2013:29) such as urban planning. Cohen *et al.* (2013:379) agree with Starman (2013) and claim that the insights gained from case-study research could be utilised in practice, therefore constituting important “knowledge-to-action” based research.

Depending on the research outcome, Yin (2009) identifies three types of case-study approaches a researcher could employ, namely 1) explanatory (e.g., explaining “how” and “why” questions), 2) descriptive (e.g., providing narrative accounts), and 3) exploratory (e.g., exploring the “what” and “how” questions). When considering the purpose of Chapter 6, the objective of the chapter is to answer, “*what ecosystem services are generated by the inventory of GI elements?*”, and secondly, “*how multi-functional are these GI elements?*”. The empirical investigation therefore employs an exploratory case-study approach.

The research method employed for the exploratory case-study exploration follows a qualitative research approach. Qualitative research focuses on gathering non-numerical data (e.g., visuals, aural and textual) with the ultimate aim of generating a new theory (Maccallum *et al.*, 2019:35). The qualitative research method is chosen as it emphasises in-depth exploration and understanding of certain phenomena (Almalki, 2016:291).

According to Yin (2009) the elementary methodology for a qualitative research method is 1) the gathering of data from a variety of resources, 2) analysing the data in order to 3) present the findings. The research methods employed for the study's exploratory case-study investigation are "qualitative sampling" for the gathering of the qualitative data and "self-assessment" as the method for analysing the data. In the following sections follow detail on these methods utilised for the identified qualitative exploratory case-study investigation.

6.3.1 Data gathering through qualitative sampling.

Best practice examples (case-studies) are selected based on a qualitative sampling technique. Qualitative sampling in a case-study approach refers to selecting the type of case-studies to be included to fit a certain purpose (Cohen *et al.*, 2013:385). The two main sampling techniques employed are 1) criterion sampling, and 2) purposeful sampling, both explained accordingly.

Criterion sampling involves selecting cases that meets a predetermined criterion (Omona, 2013:180). This sampling technique is chosen for quality insurance by collecting "information rich" case-studies (Omona, 2013:180). The predetermined criteria employed for the criterion sampling of best practice examples were provided by the inventory of GI elements generated in the literature investigation (illustrated in **Table 6-1**). The GI elements illustrated in **Table 6-1** are a representation of the GI elements listed and discussed in **Table 3-3** (c.f. 3.4). The table further illustrates the availability of case-studies of these GI elements in a South African context.

Table 6-1: Availability of South African case-studies on the criteria of GI elements.

TABLE KEY: CASE-STUDY AVAILABILITY		
HIGH	Thorough documented case-study and published information in published sources such as research articles, books, research reports, and other dissertations.	
MEDIUM	Case-study and information gathered from online reports, internet articles, media publications, and social media sites.	
LOW	No documented case-study.	
TYPES	GI ELEMENTS	CASE-STUDY AVAILABILITY
GREY-GREEN DESIGNED ELEMENTS	Green wall	MEDIUM
	Green roof	MEDIUM
	Sustainable urban drainage systems (Constructed wetland)	MEDIUM
	Sustainable urban drainage systems (Bioswales)	LOW
	Sustainable urban drainage systems (Rain garden)	MEDIUM
URBAN AGRICULTURE	Community garden	HIGH
	Vertical Farming	LOW

	Rooftop Farming	MEDIUM
	Horticulture	HIGH
URBAN NATURAL REMNANTS	Urban forest	HIGH
	Existing or remnant natural areas	MEDIUM
	Natural wetlands and ponds	HIGH
	Urban river or stream	HIGH
PUBLIC GREEN SPACE	Urban parks	MEDIUM
	Botanical garden	HIGH
	Golf course and other green sport facility (sports fields)	LOW
	Child-friendly space	MEDIUM
	Health clinic garden	HIGH
PRIVATE GREEN SPACE	Private home gardens	HIGH
INFORMAL GREEN SPACES	Riverbank greenery	LOW
	Cemeteries or burial grounds	LOW
	Roadside or railway greenery	LOW
	Vacant land	LOW

Unfortunately, as seen in **Table 6-1** the empirical investigation was limited in some instances due to a shortage of case-studies capturing GI elements within a South African context.

The gathered best practice examples of the GI elements by means of the criterion sampling technique were further refined by employing the purposeful sampling technique.

Purposeful sampling is the sampling technique that investigates all cases meeting the predetermined criteria, but only selects the cases that yield the most significant information and knowledge to contribute to the research (Patton, 1990:177; Omona, 2013:180). The purpose of selecting this technique was to ensure the selection of the most significant “information-rich” best practice examples that adhere to the predetermined criteria of GI elements.

Table 6-2 then illustrates the final selected examples of South African GI elements after the qualitative sampling techniques were employed. These cases are chosen as they adhere to the predetermined criteria and are considered “information-rich” to the South African context (more details on each best practice example follows in section 6.4).

Table 6-2: Selected best practice examples.

			BEST PRACTICE EXAMPLE
CRITERIA OF GREEN INFRASTRUCTURE ELEMENTS	Grey-green designed elements	Green roof	EThekweni Municipality Green Roof Pilot Project (Durban) and The Priority Zone rooftop garden (Durban)
		Green wall	The “Veld wall” (Rosebank, Johannesburg)
		Sustainable urban drainage systems (constructed wetland)	Intaka Island constructed wetland (Cape Town)
		Sustainable urban drainage systems (rain garden)	University of Pretoria rain garden (Pretoria)
	Urban agriculture	Community garden	Siyakhana Food Garden project (Johannesburg)
		Horticulture	Philippi Horticultural Area (Cape Town)
		Rooftop farming	The Priority Zone rooftop garden (Durban)
	Urban natural remnants	Urban forest	Johannesburg urban forest (Johannesburg).
		Existing or remnant natural areas	Rondebosch Common Urban Nature reserve (Cape Town).
		Urban wetland	Khayelitsha wetland (Khayelitsha, Cape Town).
		Urban river or stream	Liesbeek urban river (Cape Town)
	Public green space	Urban park and child-friendly space	Green point urban park (Cape Town).
		Botanical garden	Kirstenbosch Botanical Garden (Cape Town)
		Green sport facilities	Grimbeek Park Golf course and Heilige Akker sport grounds (Potchefstroom)
		Health clinic garden	The Jan Kempdorp community health centre garden (Jan Kempdorp, Northern Cape).
	Private green space	Private home gardens	Private home gardens in Cosmo city (Johannesburg)

	Informal green spaces	Riverbank greenery	Owersig riverbank green space (Potchefstroom).
		Roadside or railway verged greenery	Roadside greenery on Brakfontein road (Pretoria)

Source: Own construction (2020).

The best practice examples illustrated in **Table 6-2** are case-specific and rely on the judgement of the researcher (Palinkas *et al.*, 2015:533). Some other examples could have been selected for assessment, however, the examples selected were identified as to their availability and they exhibit the characteristic of generating numerous ESs which contribute to the quality of their local urban environment. Therefore, the chosen best practice examples ultimately serve to represent *a point of departure* to reflect on the GI elements presented.

According to Yin (2003:385) there are six possible sources for gathering data for a case-study exploration, namely, archives, interviews, participant-observation, direct observations, physical artefacts, and documents. For the purpose of this empirical investigation documentation and direct observations were utilised as sources for qualitative data gathering. The exploited documentation included gathering data for the practice examples (Table 6-2) from secondary data sources, such as books, internet articles, research articles, media outputs, research reports, other dissertations, social media sites and other published sources. The previously mentioned documents were also exploited to gather data regarding the ESs generated by the practice examples (the GI elements).

As already seen in **Table 6-1** certain GI elements presented a shortage of published material as case-studies have not yet been reported on. Nevertheless, Baxter & Jack (2008:554) recommend that to enhance the data credibility of a case-study research approach, the researcher may utilise multiple data sources as a data-gathering technique or the “triangulation” of data, meaning the collection of data from other sources as well. Therefore, in some instances, data for the case-study exploration was gathered through direct observations made by the researcher. Observations can form a significant and legitimate part of data gathering in qualitative case-study exploration (Farthing, 2016:133). More detail on the observations made follows in the following section.

6.3.2 Data analysis through self-assessment

The analysis of the qualitative data gathered occurred in two phases. Firstly, to analysing the ESs generated from the best practice examples (South African GI elements), and secondly, to determine the multi-functionality of each GI element. The research method employed is described as a “self-assessment” approach. Self-assessment of qualitative data adheres to two main

aspects, 1) identification of criteria for the assessment, and 2) determination of the extent to which criteria are met (Boud & Falchikov, 1989:529). For the first phase of the assessment (in this case the analysing the ESs generated by the best practice examples) the GI elements were assessed according to the extent to which each best practice example meets the criteria of ESs identified in the literature investigation (Chapter 4) (c.f. Table 4-2). The assessment was undertaken by means of a “simple matrix” format, linking each GI element with the criteria of ESs (refer to section 6.4.1). The self-assessment was made based on the assessment of the qualitative data gathered from the documents, as well as direct observations made by the researcher. The technique employed for direct observations was a “passive observation” approach, meaning researcher employed intuition to gather data such as field notes and photographs of the phenomena being explored (Maree, 2020:105). The GI element directly observed by the researcher was considered and a judgement was made regarding the extent a particular GI element provides each ES.

Based on the results gathered in the first phase of the assessment, the second phase includes the self-assessment of the “level” of ESs recognised within the four ESs categories. The assessment was completed based on **Table 6-3**.

Table 6-3: The ranking scale for assessing the level of ecosystem services recognised within the four ecosystem services categories.

ASSESSMENT RANKING AND COLOUR	THE LEVEL OF ECOSYSTEM SERVICES RECOGNISED WITHIN THE FOUR CATEGORIES (Provisioning, regulating, cultural and habitat and supporting services)
0 – very weak	No ecosystem services recognised within a category
1 – weak	One of the ecosystem services recognised within a category - <i>Weak</i>
2 – medium	Two of ecosystem services recognised within a category - <i>Medium</i>
3 – strong	Three or more of the ecosystem services recognised within a category- <i>Strong</i>

Source: Own construction (2020).

If none of the ESs of a category was recognised within the GI element, a ranking of 0 (very weak) was allocated for the ES category. A ranking of 1 (weak) was allocated if one of the ESs were recognised, and 2 (medium) was allocated for an ES category if two ESs were recognised within the category. When three or more ESs were recognised within a category, the category was ranked as a 3. As illustrated in **Table 6-3**, a corresponding colour is awarded, for illustration purposes, to each rating item. Thereafter, the multi-functionality of each of the GI elements was assessed.

A level of multi-functionality was allocated for each GI element. The level of multi-functionality determination was made according to the recognised ESs category levels. As proposed in **Table 6-4**, if only one ES category was ranked with a level-3 rating (according to Table 6-3), the GI elements indicated a “mono-functionality level” (serve only one particular function). If a GI element

ranked with two or three level-3 ratings (according to Table 6-3) a “low-level” or a “medium-level multi-functionality” was allocated. When all four ES categories (the maximum ES categories) indicated a level- 3 rating according to Table 6-3, then the GI was indicated as “high multi-functionality”.

Table 6-4: The rankings allocated for assessing the multi-functionality of each Green Infrastructure element.

NUMBER OF ECOSYSTEM SERVICE CATEGORIES RECOGNISED	ASSESSMENT OF THE MULTI-FUNCTIONALITY LEVEL
<i>One ecosystem service category</i>	Mono-functional
<i>Two ecosystem service categories</i> with a ranking of 3	Low level multi-functionality
<i>Three ecosystem service categories</i> with a ranking of 3	Medium level multi-functionality
<i>All (four) ecosystem categories</i> with a ranking of 3	High level multi-functionality

Source: Own construction (2020).

In the remaining sections the chapter include the discussions on the qualitative data gathered and analysed. Section 6.4 follows the discussion on the data gathering and analysis of the “provision capacity” or the ESs generated by the chosen best practice GI elements, while Section 6.5 assesses the multi-functionality of the different GI elements.

6.4 Phase 1 - Data gathering and analysis of the ecosystem services generated by the chosen best practice GI elements.

As previously mentioned, the purpose of this section is to self-assess the five main GI element groups and 19 best practice GI elements examples. Data in the form of text and figures were gathered to describe each of the best practice examples. The background of each best practice is briefly introduced. The ESs recognised within each GI element are described by text and indicated by employing a checkbox in a matrix format. This self-assessment is presented in the following sections of the empirical investigation.

6.4.1 Investigation into the ESs provision capacity of the grey-green designed GI elements

As found in the literature investigation, grey-green designed elements are not yet well implemented in a South African context (c.f. 3.3.2.2). A few excellent locally implemented grey-green designed elements examples include green roofs, a green wall, and sustainable urban drainage systems. The best practice examples of these South African grey-green designed elements and their recognised ecosystem services follow.

6.4.1.1 Assessment of the green roof best practice example

Two best practice examples were chosen to assess the ESs generated by green roofs, namely 1) EThekwini Municipality Green Roof Pilot Project and 2) the Priority Zone rooftop garden. Both these green roof examples are located within the city of Durban, South Africa. The EThekwini Municipality Green Roof Pilot Project was generally created and motivated by climate adaption and mitigation strategies (van Niekerk *et al.*, 2011:5), the Priority rooftop garden is a best practice example for the GI element – rooftop farming, as part of the urban agriculture GI elements group. Both the green roof examples indicated the delivery of numerous ESs and are indicated in **Table 6-5**.

Table 6-5: Self-assessment of the ESs generated by green roofs.

GREEN ROOF/ ROOFTOP FARMING				
1) EThekwini Municipality Green Roof Pilot Project		Physical location		
		Durban, KwaZulu Natal, South Africa		
		Location within the city		
		Buildings in the City Engineers complex. Priority Zone headcounters building (Durban CBD).		
2) The Priority Zone (PZ) Rooftop garden		Access		
		1) Private 2) Public		
		Initiated		
		1) 2009 2) 2013		
CRITERIA	Provisioning	Food supply	10m ² of the EThekwini Municipality Green Roof Pilot Project is planted with a broad spectrum of vegetables and herbs. An average of 43.4 kilograms of vegetables are harvest from the roof. The PZ rooftop garden produces food to supply to the homeless and charity organisations.	✓
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	The PZ rooftop garden cultivates herbs that could be employed for medicinal purposes.	✓

Source: SA roofing (2013:10).

	Regulating	Local climate regulation	The cooling effect of the plants (evapotranspiration) reduces building temperature along with the demand for energy intensive cooling and hence greenhouse gas emissions.	✓
		Air Purification	Plants absorb carbon dioxide (greenhouse gasses), photosynthesise and release oxygen. The eThekweni Municipality Green Roof Pilot Project removes up to 100 kilograms' particulate matter evidently to emitted by 92 vehicles per year.	✓
		Moderation of Extremes	Large roof planting reduces the urban heat island affect by absorbing heat through plants. Average temperature above green roof 22°C vs black roof 41°C.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	The PZ rooftop garden creates a place for people to meet, socialise, and relax. The rooftop garden also provides recreational activities such as chess games, as well as exercise classes.	✓
		Aesthetic contributions	Both green roofs are considered as attractive, brings nature into the monotony concrete buildings of the urban centre.	✓
		Spiritual experience and sense of place	Vegetation on both of the green roof proved to calm employees, improving their happiness, and reducing depression.	✓
		Tourism/economic contribution	The PZ rooftop garden is open to visitors and attracts tourism. Moreover, the products grown, managed, and sold with the PZ rooftop garden creates employment opportunities.	✓
	Habitat & supporting	Habitats for species	Provides important natural habitats for birds, reptiles, and insects within the Durban urban area.	✓
		Genetic diversity	The main aim of the roof was to increase Durban's biodiversity. Diverse choice of indigenous plants was used that attracted a large number of insects (2,898 in total) and a number of birds.	✓

Source: Own construction based on eThekweni Municipality (2011:11); Priority Zone Durban (2013); Pillay (2017).

6.4.1.2 Assessment of the green wall best practice example

Green walls were the second grey-green design element assessed. The chosen best practice example for the assessment of a green wall is the “Veld wall” green wall located in Rosebank, Johannesburg, South Africa. This particular green wall covers the front of the St. Teresa’s School, in Rosebank (Pro Landscaper Africa, 2018:37). The “Veld wall” is considered as “nature conservation in art form”, planted with indigenous vegetation with which the area was covered, before the effects of urbanisation (Knoll, 2018:29). The ESs recognised with the “Veld wall”-green wall are indicated in **Table 6-6**.

Table 6-6: Self-assessment of the ESs generated by the "Veld wall"- green wall.

GREEN WALL				
The 'Veld wall', Johannesburg			Physical location	
			Rosebank, Johannesburg, South Africa	
			Location within the city	
			St. Teresa's School, Keyes Avenue	
			Access	
			Public and commercial	
			Initiated	
			2018	
Source: Knoll (2018) and Pro Landscaper Africa (2018).				
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	Contributes to favourable microclimate, such as creating insulation and cooling the school building as well as causing shade over other adjacent buildings.	✓
		Air Purification	The planting palette aids carbon sequestration within the urban area	✓
		Moderation of Extremes	N.A.	✗
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	Cognitive development- The green wall enhances the conservation of nature and the locally indigenous plants. The wall is furthermore employed in the St Teresa' Schools biological classes for scholars to learn about nature and ecosystems.	✓
		Aesthetic contributions	The wall has the appearance of biodiversity, with seasonal changes adding "living art" to the Keyes Art Mile.	✓
		Spiritual experience and sense of place	The wall was created to reflect the appearance and value of nature and biodiversity conservation value of endangered grass species in the area. The variety of plant species included in the wall are relatively unknown to the general public and therefore catches their attention.	✓
		Tourism/ economic	The pavement level greenery of the wall creates a retail precinct attracting small shops, cafes, and restaurants. The aesthetics of the wall enhances the local economy by attracting more people to the facilities around the wall.	✓
Habitat & supporting	Habitats for species	The green wall was designed to accommodate some of the highly endangered plant species from the Highveld. Rosebank is situated in the Grassland biome and the wall was therefore created to include grass species from the endangered Egoli Granite Grassland vegetation unit.	✓	
	Genetic diversity	A number of 5070 plants are included in the Veld wall, including grass species, as well as small shrubs, succulents, and perennials. Insect species been spotted included bees and nectar-feeding sunbirds and other bird species.	✓	

Source: Own construction based on Knoll (2018) and Pro Landscaper Africa (2018).

6.4.1.3 Assessment of the sustainable urban drainage systems best practice example

Intaka Island is an artificially created wetland located in the Century City development, Cape Town. The constructed wetland, mimicking a natural wetland to generate important ESs. The ESs recognised within the Intaka Island constructed wetland are illustrated in **Table 6-7**.

Table 6-7: Self-assessment of the ESs generated by the Intaka Island constructed wetland.

CONSTRUCTED WETLAND				
Intaka Island – ‘Bird island’ 8ha constructed wetland zone. 		Physical location		
		Cape Town, South Africa		
		Location within cities		
		Cape Peninsula, Century city development		
		Access		
		16ha, multi-purpose nature area		
		Initiated		
		1996		
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	Providing water for plant and animal species, as well as domestic use.	✓
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	N.A.	✗
		Air Purification	The wetland contributes to carbon sequestration, therefore improving air quality	✓
		Moderation of Extremes	“Low flow” and “high flow” systems were designed within the wetland in order to accommodate both normal flows, as well as storm water caused by flooding events.	✓
		Waste-water treatment	Includes a system (engineered combined with ecological resources) that filtrates, purify and recycle water. Serves as essential “health operator” for ensuring quality water in Century City. “Low flow” systems were especially designed to capture polluted rainwater runoff to be purified in a detention pond and are thereafter discharged into the ocean.	✓
	Cultural	Recreation and cognitive development	Provides both educational and recreational activities, including pathways constructing for walks around the wetland and bird hides for bird watching. The area has become a popular space for school groups, learning about the environment.	✓
		Aesthetic contributions	Consider a “green lung” in a highly developed urban area of Cape Town.	✓
		Spiritual experience and sense of place	It has a “sense of community” offering a “stress-free” place where people can relax, unwind, enjoy, and connect with the nature the wetland offers.	✓
		Tourism	Has a high commercial and economic value attracting various visitors and an overall positive economic sustainable spill over to the broader Century City development, provides for instance employment opportunities and property values increased, accent to the wetland.	✓

	Habitat & supportin	Habitats for species	Constructed an artificial habitat for the heronry, known as the "Weyers Platforms" on the shore to accommodate for a variety of bird species, providing ideal conditions for nesting and breeding.	✓
		Genetic diversity	Habitat for over 200 species of indigenous Fynbos plants and more than 120 species of birds.	✓

Source: Own construction based on University of Cape Town (2004); Planning Partners (2005); Wynne-Jones (2005); Mallett, 2017.

In addition, a sustainable urban drainage system assessed on a smaller scale than the above-assessed constructed wetland (**Table 6-6**) was a rain garden best practice example. The University of Pretoria was challenged with issues of waterproofing and inadequate storm water infrastructure (Steenberg, 2013:24). The recommendation was the construction of an on-site rain garden that could serve as a water retention facility collecting water from roofs and surrounding impermeable surfaces (Footprint Limited, 2014). The main focus of the rain garden was to create a landscape that is not merely beautiful but also serves an ecological function towards solving urban environmental problems (Dunstan & Sampson, 2013). According to Steenberg (2013:26), the rain garden project by the University serves as an example where grey infrastructure (in this case a building) could be merged with the natural landscape. The ESs recognised within the University of Pretoria rain garden are illustrated in **Table 6-8**.

Table 6-8: Self-assessment of the ESs generated by the University of Pretoria rain garden.

RAIN GARDEN				
University of Pretoria rain garden				
		Physical location		
		Pretoria, South Africa		
		Location within the city		
		University of Pretoria		
		Access		
		Public		
		Initiated		
		2013		
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	The captured water is infiltrated back into the ground, which is then utilised for the irrigation of the botanical garden. The system harvests 17 000l water for every 10mm of rain of the 1700m ² building.	✓
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	Evapotranspiration reduces energy usage and mitigating the urban heat island.	✓
		Air Purification	On a small scale provides local air purification through the vegetation, tree cover acts as carbon storages.	✓

Source: Dunstan and Sampson (2013); Steenberg (2013).

		Moderation of Extremes	On a small scale prevents storm water flooding by capturing the storm water of the already overloaded storm water infrastructure.	✓
		Waste-water treatment	Serves as a rainwater harvesting and water treatment plant for the botanical garden. Water is filtered and circulated through the plants in the garden.	✓
	Cultural	Recreation and cognitive development	The created ecosystem serves as a “living laboratory” for students to research the wetland habitat. It also provides the opportunity to safeguard some plant species utilised for horticultural research.	✓
		Aesthetic contributions	A previously degraded and unused space around the building is created into a visually and intellectually stimulating green space.	✓
		Spiritual experience and sense of place	N.A.	✗
		Tourism	The space was created to attract visitors and has especially become a favourite attraction for students	✓
	Habitat	Habitats for species	By softening the hard lines of the building with green resources created a habitat for fish, insects, and amphibians. All trees found on the site was incorporated into the design.	✓
		Genetic diversity	Host approximately 145 aquatic and terrestrial plant species	✓

Source: Own construction based on Dunstan and Sampson (2013); Steenberg (2013); Footprint Limited (2014).

6.4.2 Investigation into the ESs provision capacity of the urban agriculture GI elements

Best practice examples on urban agriculture GI elements includes examples of a South African community garden, horticulture, and rooftop farming example. As previously discussed, the green roof best practice example, The Priority Zone rooftop garden (discussed and assessed in 6.4.1.1) served as the rooftop farming best practice example. The following section discusses and assess the remaining best practice examples of South African urban agriculture GI elements.

6.4.2.1 Assessment of the community garden best practice example

In 2005 the Siyakhana Food Garden project was initiated to supply fresh food products (fruit and vegetables) to the Siyakhana group that includes Childhood Development Centres (EDC's) and Home-Based Care (HBC) organisations within the inner areas of Johannesburg, South Africa (Nicolle, 2011:30). However, today, the benefits of the garden extend beyond the Siyakhana group with considerable potential for the local community (Bauta *et al.*, 2011:6). The garden is formerly referred to as the “Siyakhana initiative” and is regarded as one of the most prominent urban agricultural sites within the city of Johannesburg (Bauta *et al.*, 2011:6) In addition to food production, the garden is also considered as a “living laboratory” offering other activities and is considered to be more than a food garden, but an initiative with an “ecological perspective on health promotion” for the local community (Nicolle, 2011:149). The ESs recognised within the Siyakhana initiative are illustrated in **Table 6-9**.

Table 6-9: Self-assessment of the ESs generated by the Siyakhana Food Garden project.

COMMUNITY GARDEN				
Siyakhana Food Garden project 		Physical location		
		Inner city of Johannesburg, South Africa		
		Location within the city		
		Periphery of residential neighbourhood-Bezuidenhout Valley		
		Access		
		Public		
		Initiated		
		2005		
CRITERIA	Provisioning	Food supply	One of the main objectives is to grow healthy and organic food. More than 40 varieties of food and medicinal plants are grown.	✓
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	Both plants and herbs are cultivated in the garden and utilised for medicinal purposes.	✓
	Regulating	Local climate regulation	The food garden has the potential to minimise the urban heat island effect by lowering temperature in the area.	✓
		Air Purification	Contributes to air purification on a local scale by reducing the carbon footprint through the vegetation that acts as carbon storages, but ultimately add to the network of GI elements that together provides air purification for the inner city of Johannesburg.	✓
		Moderation of Extremes	Could contribute to flood reduction by infiltrating storm water directly into the ground.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	Considering the garden as a “living laboratory” seeing that it offers practical training activities in food gardening. Furthermore, interactive walks through the garden enables the sharing of knowledge on permaculture and ecological health. Six schools from the inner Johannesburg city also participates in the gardening initiative.	✓
		Aesthetic contributions	N.A.	✗
		Spiritual experience and sense of place	Through interaction with the garden creates awareness among the local community on social change, as well as healthier lifestyles. Furthermore, promotes social integration and mental health improvement.	✓
		Tourism/ economic development	Provides visitors activities (recreation and cognitive development). Furthermore, the food garden creates self-sufficiency and jobs within the community.	✓
	Habitat	Habitats for species	N.A.	✗
		Genetic diversity	Increases urban biodiversity.	✓

Source: Own construction based on Nicolle (2011); Bauta *et al.* (2011); Nino *et al.* (2020).

6.4.2.2 Assessment of the horticulture best practice example

In contrast with the small-scale community garden best practice example of the previous section (Siyakhana initiative), the following best practice example is an example of a “city-based

production” horticulture area, namely the Philippi Horticultural Area located within a neighbourhood of the Cape Flats (Cape Town) (Donn-Arnold, 2019:60). The Philippi Horticultural Area is a large open space that grows a variety of 45 types of horticultural products contributing to the food security of various communities located on the outskirts of the area (Battersby-Lennard & Haysom, 2012). The space is responsible for producing almost 100 000 tons of freshly produced vegetables per year to Cape Town retail stores and local communities (Dewar *et al.*, 2013; Donn-Arnold, 2019:60). Other products include flower and shrub farming, some cattle farming as well as seedlings (Donn-Arnold, 2019:55). The Horticultural site is located in an area with limited green spaces and therefore provides important ESs essential to the local environment and residents' well-being (Battersby-Lennard & Haysom, 2012:31). The ESs recognised within the Philippi Horticultural Area are illustrated in **Table 6-10**.

Table 6-10: Self-assessment of the ESs generated by the Philippi Horticultural Area.

HORTICULTURE				
 Philippi Horticultural Area Source: Haysom <i>et al.</i> (2017:37).		Physical location		
		Cape Town, South Africa		
		Location within the city		
		Cape Flats		
		Access		
		Public		
		Initiated		
		Producing food for more than 150 years		
CRITERIA	Provisioning	Food supply	Fertile soil of the area provides the opportunity to produce a large quantity and variety of food products (especially vegetable products).	✓
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	The space links with a network of other green space (nature reserves, storm water systems, the False bay coast, a Wetland park forming a “green web”) that together generate ecological functions. On local scale planted trees for shade and wind protection and absorbing heat in the urban area.	✓
		Air Purification	The space links with a network of other green space (nature reserves, storm water systems, the False bay coast, a Wetland park forming a “green web”) that generated together ecological functions. Serves as a “green lung” for the local surrounding neighbourhoods.	✓
		Moderation of Extremes	The space links with a network of other green space (nature reserves, storm water systems, the False bay coast, a Wetland park forming a “green web”) that generated together ecological functions.	✓
		Waste-water treatment	The area is situated on the Cape Town Aquifer and is considered as an aquifer recharge area that directly infiltrates rainwater back into the ground.	✓

	Cultural	Recreation and cognitive development	Provides amenities such as nurseries and an educational environment. The space furthermore serves as some refuge for young people to learn about the environment and food production.	✓
		Aesthetic contributions	The Horticultural site is located in an area with limited green spaces and therefore provides natural beauty in the area.	✓
		Spiritual experience and sense of place	Horticulture may facilitate personal healing and transformation developing emotional inelegancy and creating a sense of purpose among people, as well as some social integration.	✓
		Tourism	<i>N.A.</i>	✗
	Habitat	Habitats for species	The area has high biodiversity density because of the Cape Town Aquifer source	✓
		Genetic diversity	<i>N.A.</i>	✗

Source: Own construction based on Battersby-Lennard & Haysom (2012); Dewar et al. (2013); Donn-Arnold (2019).

6.4.3 Investigation into the ESs provision capacity of the urban natural remnants GI elements

Four “natural remnants” GI elements were assessed, namely an existing or remnant natural area best practice example, an urban forest best practice example, an urban wetland, and an urban river or stream best practice example. The assessment of the ESs generated from these existing or remnant natural areas best practice examples follows respectively in the following sections.

6.4.3.1 Assessment of the urban forest best practice example

The chosen best practice example for the urban forest GI element is considered as the world’s largest urban forest and an “ecological asset” to the city of Johannesburg, South Africa (Schäffler & Swilling, 2013:248). Approximately six million trees are part of the Johannesburg urban forest – 1.2 million of these trees are found in parks and street pavements, while 4.8 million grow in suburban private gardens (Johannesburg Urban Forest Alliance, 2018:4). The ESs recognised within the Johannesburg urban forest are illustrated in **Table 6-11**.

Table 6-11: Self-assessment of the ESs generated by the Johannesburg urban forest.

URBAN FOREST	
The “world’s largest man-made urban forest” – Johannesburg urban forest 	Physical location
	Johannesburg, South Africa
	Location within the city
	City of Johannesburg. ±16.1% of the city’s 164 458ha is covered by trees
	Access
	Publicly managed
Initiated	
19 th century	

Source: Schäffler & Swilling (2013).

CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	Raw materials, such as wood are delivered by the urban forests and could be consumed as material.	✓
		Fresh water	N.A.	✗
		Medicinal resource	Indigenous trees found within the urban forest provide natural resources for traditional healers which relying on “age-old ethno-botanical practice” such as bark harvesting.	✓
	Regulating	Local climate regulation	Mitigation of the urban heat island effect by tree-shading, intercepting solar radiation, and absorbing heat in the urban area.	✓
		Air Purification	The initial rational of the forest was and is still to improve air quality by removing air pollutants by the trees.	✓
		Moderation of Extremes	Plays an important role in reducing effects of flooding caused by intense Highveld thunderstorms (local precipitation) by intercepting rainwater and reducing storm water runoff.	✓
		Waste-water treatment	The trees remove acid water from the city’s sewer systems, wastewater treatment caused by old mines and contaminating groundwater.	✓
	Cultural	Recreation and cognitive development	Enhance citizens’ interaction with GI and a bottom-up source of ecological knowledge among the citizens.	✓
		Aesthetic contributions	The trees form a unique “soft ecological space” in the concrete urban environment.	✓
		Spiritual experience and sense of place	The forest has the ability to advance “a sense of calm and quality of life” within the busy urban life.	✓
		Tourism	The urban forest contributes to investment, including jobs, revenue, and knowledge along with the enhancement of gardening services, landscape business and nurseries.	✓
	Habitat & support	Habitats for species	Serve as habitat for various bird species seeking refuge in the urban area.	✓
		Genetic diversity	Variety of non-indigenous species, including species such as Eucalyptus, Black Wattle, Jacaranda, Oaks, and Pepper trees.	✓

Source: Own construction based on Schäffler & Swilling (2013).

6.4.3.2 Assessment of the existing or remnant natural areas best practice example

The chosen existing or remnant natural area best practice example is a nature reserve surrounded by residential areas, schools, roads, and hospitals, namely the Rondebosch Common Urban Nature reserve, located in the Southern suburbs of Cape Town (COCT, 2010:34). Rondebosch Common is a public open space with important ecological functions (COCT, 2010:34). The nature reserve conserves almost 40 Hectare remnants of the critically endangered Cape Flats Sand Fynbos vegetation species, as well as a scarce seasonal wetland habitat type (Dyssel, 1993:84). The ESs recognised within the Rondebosch Common Urban Nature reserve are illustrated in **Table 6-12**.

Table 6-12: Self-assessment of the ESs generated by the Rondebosch Common Urban Nature reserve.

EXISTING OR REMNANT NATURAL AREAS				
CRITERIA		Rondebosch Common nature reserve		Physical location
				Cape Town, South Africa
				Location within the city
				Southern suburbs (Rondebosch) of Cape Town
				Access
				Public
				Initiated
				-
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	Contributes to the mitigation of the urban heat island.	✓
		Air Purification	On a small scale provides local air purification through the vegetation, tree cover that acts as carbon storages, but ultimately add to the network of GI elements that together provides air purification for the urban area of Cape Town.	✓
		Moderation of Extremes	The natural vegetation is important for storm-water run-off regulation and infiltration of rainwater into soil and catchment areas in the high-density urban area.	✓
		Waste-water treatment	The presence of the seasonal wetland holds ecological value.	✓
	Cultural	Recreation and cognitive development	"Informal recreational use" - the path around Rondebosch common are a local attraction for joggers and cyclists. The reserve also provides the opportunity to appreciate nature, as well as Table Mountain in the background. Wildlife watching, spring-flower spotting, and information boards regarding the nature life – encourages environmental education.	✓
		Aesthetic contributions	The aesthetic aspect of the Rondebosch Common nature reserve is an important asset as one of the few natural remnants within the Cape Metropolitan area with a view of Table Mountain. The annual show of spring flowers also offers an aesthetically appealing site.	✓
		Spiritual experience and sense of place	A relaxing area to experience nature. The reserve is without barriers and therefore has an open and inviting character enhancing the special character of the area.	✓
		Tourism	Proclaimed as a National Monument because of its historical significance as a military camping ground.	✓
	Habitat & supportin	Habitats for species	Considered as a sanctuary, one of the few nature remnants of the critically endangered Cape Flats Sand Fynbos. The included seasonal wetland supporting interesting species.	✓
		Genetic diversity	Small mammals and over a 110 species of birds. At least nine red data plants species are conserved in the reserve	✓

Source: Own construction based on Dyssell, 1993; COCT (2010).

6.4.3.3 Assessment of the urban wetland best practice example

The Khayelitsha urban wetland is located within the urban area of Khayelitsha, surrounded by a built-up area of informal settlements, roads, and low-cost housing (COCT, 2016). Listed as a

Critical Biodiversity Area (CBA) (c.f. 3.3.2.2), the wetland is of great conservation value offering both functional and cultural benefits to the local urban dwellers (African Centre for a Green Economy, 2017:21). In 1998 the Khayelitsha Wetland Park was developed as part of the greater Khayelitsha wetland area (COCT, 2016). What was once a litter-strewn wetland has been developed into a 45 Hectare park showcasing of sustainable development (COCT, 2016). According to the African Centre for a Green Economy (2017:9) the park is an excellent example of how a green space could be conserved and incorporated into an overcrowded and lower-income area of a city. The ESs recognised within the Khayelitsha wetland are illustrated in **Table 6-13**.

Table 6-13: Self-assessment of the ESs generated by the Khayelitsha wetland.

NATURAL WETLANDS AND PONDS				
Khayelitsha Wetlands				Physical location
				Cape Town, South Africa
				Location within the city
				Urban area of Khayelitsha
				Access
				Public
				Initiated
				1998
CRITERIA	Provisioning	Food supply	The wetland field is employed as a grazing field for the community's livestock. Some plant species found within the wetland are also considered as "food plants" used by the community.	✓
		Raw materials	The community depends on material practices provided and harvested from the wetland	✓
		Fresh water	The wetland provides water for the local communities' livestock, and for irrigation and human use (swimming, canoeing, and baptising). The role of Khayelitsha's wetland is critical for providing quality water for downstream usage.	✓
		Medicinal resource	A certain plant species found within the wetland area is employed as medicine by traditional healers.	✓
	Regulating	Local climate regulation	The high concentration of vegetation, as well as the waterbody contributes to the mitigation of the urban heat island effect, intercepting solar radiation, and absorbing heat in the urban area.	✓
		Air Purification	The high concentration of vegetation in the Khayelitsha wetland contribute local air purification.	✓
		Moderation of Extremes	The groundcover of the Khayelitsha wetland, as well as absorption function of plants offers the special function of the natural uptake of storm water preventing flood hazard while recharging groundwater sources.	✓

Source: COCT (2016); Mathenjwa (2017).

		Waste-water treatment	Fulfil the ecological role of water purification. Create amounts of pollutant water captured, to be temporarily stored and purified in the Khayelitsha wetland, before flowing into the ocean.	✓
	Cultural	Recreation and cognitive development	<i>Recreation</i> - The park incorporated into the Khayelitsha wetland is the motive for recreational services, for instance trails for joggers and cyclists, a child-friendly playground and skate park, outdoor gym, soccer field. <i>Cognitive development</i> – The Khayelitsha canoe club offers educational tours of the wetland.	✓
		Aesthetic contributions	Aesthetically pleasing with environmentally friendly landscape design (garden).	✓
		Spiritual experience and sense of place	The community of Khayelitsha plays a key role in protecting the ecosystem, therefore the park is created in a manner to empower the community and create local opportunities through which the community could benefit from. Likewise, tourist opportunities and the aesthetic element of the wetland have improved the community of Khayelitsha. The wetland also provides spiritual practices such as baptisms.	✓
		Tourism	Considered as a hub for ecotourism. Youth of the local community created a canoeing business.	✓
	Habitat & supporting	Habitats for species	The wetland contributes to increased biodiversity and conservation. Plants found within the wetland area provides important shelter and nesting habitat for migrating birds and other bird species. Moreover, the wetland supports nurseries for several freshwater fish species and other species such as frogs and aquatic organism.	✓
		Genetic diversity	The wetland hosts many plant and animal species.	✓

Source: Own construction based on COCT (2016); African Centre for a Green Economy (2017); Mathenjwa (2017).

6.4.3.4 Assessment of the urban river or stream best practice example.

The Liesbeek River is located in one of the urbanised river valleys in South Africa (Brill *et al.*, 2017), surrounded by a diversity of land-uses and suburbs along the socio-economic gradient (Fisher-Jeffes *et al.*, 2017). The river is considered as a “biodiversity corridor” forming part of Cape Town’s Metropolitan Open Space System (MOSS) (Bhikha, 2013) serving an important ecological role and representing an attractive recreational open waterbody space (Muntjewerff *et al.*, 2019:3). Moreover, The Liesbeek River together with another urban river – The Black River – falls within the boundary of the Two Rivers urban park, providing a variety of cultural and ecological needs of the southern suburbs of Cape Town (Bhikha, 2013). According to Kotzé (2020), the river is an excellent example of how GI could solve modern-day urban challenges of storm water and climate change. The ESs recognised within the Liesbeek River are illustrated in **Table 6-14**.

Table 6-14: Self-assessment of the ESs generated by the Liesbeek river.

URBAN RIVER OR STREAM				
The Liesbeek river 			Physical location	
			Cape Town, South Africa	
			Location within the city	
			Southern suburbs of Cape Town	
			Access	
			Public	
			Initiated	
			-	
Source: Kotzé (2020).				
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	Historically acted as water resource for agricultural purposes.	✓
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	Microclimate regulation – the waterbody has a high heat capability and the vegetation along the river has additional cooling effects.	✓
		Air Purification	The waterbody and high concentration of vegetation in the river contributing to chance of local air purification	✓
		Moderation of Extremes	Mitigate storm water runoff.	✓
		Waste-water treatment	The river plays an important role in improving water quality by capturing sediments and removing toxicants.	✓
	Cultural	Recreation and cognitive development	Most of the river is canalised and offers a trail way alongside for walking, as well as benches, for seating and viewing. Serves as living laboratory	✓
		Aesthetic contribution	The riverbank gardens create a pleasant atmosphere and aesthetic pleasing site – “bringing nature back into the city”.	✓
		Spiritual experience and sense of place	The river as part of the Two Rivers urban park poses a strong sense of place.	✓
		Tourism	As part of the Two Rivers urban park, offers heritage buildings and a recreational space, attracting visitors.	✓
	Habitat & supporting	Habitats for species	Provide a habitable space. A part of the river is located in the Raapenberg Bird Sanctuary nature reserve, an important breeding site for many duck species, as well as a conserved area for natural riparian conditions.	✓
		Genetic diversity	The river is a part of the city of Cape Town’s biodiversity network in both fauna and flora.	✓

Source: Own construction based on Bhikha (2013), Brill *et al.* (2017), Fisher-Jeffes *et al.* (2017), Muntjewerff *et al.* (2019), Kotzé (2020).

6.4.4 Investigation into the ESs provision capacity of public green spaces

The fourth main GI element group assessed is public green spaces. An urban park and child-friendly space, botanical garden, green sports facilities, and a health clinic garden are included under the public green spaces group and are accordingly discussed and assessed.

6.4.4.1 Assessment of the urban park and child-friendly space best practice example

In South Africa, different types of urban parks are often combined (Landman, 2019:75) for instance child-friendly spaces are often considered as a component of urban parks (Cilliers & Goosen, 2016:794). The chosen best practice example for a South African urban park is the Green Point urban park, Cape Town. The park would be classified under the Redbook (CRSI, 2019) “type of parks” (c.f. Table 3-3) as a Regional or district Park. The urban park is an excellent local example of a multi-functional urban regional park providing more than just recreational activities (cultural ESs) to more than one group of people and therefore meeting a wide range of needs. The ESs recognised within the Green Point urban park are illustrated in **Table 6-15**.

Table 6-15: Self-assessment of the ESs generated by the Green Point urban park.

Table 6-15: Self-assessment of the ESS generated by the Green Point urban park				
URBAN PARKS/CHILD-FRIENDLY SPACE				
Green point urban park (Regional Park) 			Physical location	
			Cape Town, South Africa	
			Location within the city	
			Green point	
			Access	
			Public	
			Initiated	
			2010	
Source: City of Cape Town (2016).				
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	The park includes a wetland garden providing fresh and clean water from streams flowing from Table Mountain	✓
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	On a small scale provides local climate regulation through the vegetation, tree cover and water features contributing to the cooling effect. Ultimately, the park adds to the network of GI elements that together provide local climate regulation.	✓
		Air Purification	On a small scale provide local air purification through the vegetation. Trees cover that acts as carbon storages, but ultimately add to the network of GI elements that together provides air purification for the urban area of Cape Town.	✓
		Moderation of Extremes	N.A.	✗
		Waste-water treatment	The included wetland infiltrates, purify and recycle water from streams flowing into the wetland.	✓
	Cultural	Recreation and cognitive development	<i>Recreation</i>- the park offers different areas for activities for different people, for instance two playparks for children. One playpark designed for toddlers, and another one for primary school students. Other recreational activities provided by the park include pathways for joggers and cyclist, picnic areas, and an open-air theatre and outdoor fitness park. <i>Cognitive development</i> -The showcase biodiversity garden is divided into “people and plants,” “wetlands” and “discovering	✓

			biodiversity” garden beds offering information boards for educational purposes and school tours.	
		Aesthetic contributions	The biodiversity garden, as well as water features contribute to an aesthetically pleasing area, along with a view of Table Mountain.	✓
		Spiritual experience and sense of place	The included “biodiversity garden” is safe and provides a relaxed area for visitors to experience and value the diversity of plants and animal species.	✓
		Tourism	Well-known tourist attraction seeing the variety of activities and attractions provided by the park.	✓
	Habitat & supportin	Habitats for species	The included wetland attracts a diversity of birds and insects	✓
		Genetic diversity	One of the City of Cape Town’s Local Action for biodiversity projects by including a “biodiversity garden” filled with a variety of fauna and flora within the park (25 000 indigenous tree species, shrubs, and groundcovers and 300 plant species).	✓

Source: Own construction based on Landman (2019), City of Cape Town (2016).

6.4.4.2 Assessment of the botanical garden best practice example

The chosen best practice example for a South African botanical garden is the Kirstenbosch Botanical Garden, located in Cape Town. The Kirstenbosch Botanical Garden is one of ten South African botanical gardens and is considered as one of the top 10 botanical gardens in the world (King, 2020:46). The development of the garden has a long history, unduly the Kirstenbosch botanical garden is situated in one of the world’s “biodiversity hotspots” and was designed to conserve, display, and research some of South Africa’s unique indigenous plants (Willis, 2013). Situated on the slopes of Table Mountain, the garden forms part of the Table Mountain National Park and Cape Floristic Region World Heritage Site (Huntley, 2012). Furthermore, the garden is unique in the sense that it preserves unique flora indigenous to South Africa boasting the rich biodiversity of the Cape floral region (King, 2020:46). The ESs recognised within the Kirstenbosch botanical garden are illustrated in **Table 6-16**.

Table 6-16: Self-assessment of the ESs generated by the Kirstenbosch botanical garden.

BOTANICAL GARDEN	
Kirstenbosch National Botanical Garden	
	Physical location
	Cape Town, South Africa
	Location within the city
	Eastern slopes of Table Mountain
	Access
	Public
Source: King (2020).	Initiated
	1913

CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	Natural forested areas of the garden could store and purify water.	✓
		Medicinal resource	Many species with medicinal value are found. They are cultivated in the garden and can be bought at the garden's nursery.	✓
	Regulating	Local climate regulation	Mitigation of the urban heat island effect by tree-shading, intercepting solar radiation, and absorbing heat in the urban area.	✓
		Air Purification	The Kirstenbosch indigenous forest provides excellent ecological processes.	✓
		Moderation of Extremes	The ground vegetation offers a special absorption function of storm water run-off from the slopes of Table Mountain, contributing to preventing flood hazard while recharging groundwater sources.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	Plays an important educational role and a resource for botanical, environmental and conservation research. Visitors explore the fauna and flora, as well as other recreational activities such as taking recreational walks along the paths, bird watching, visiting the restaurants, hiking trails, open theatre shows and art exhibitions, lawns for picnics.	✓
		Aesthetic contributions	Kirstenbosch National Botanical Garden are well-known for its appeal and scenic natural beauty.	✓
		Spiritual experience and sense of place	To relax and rejuvenate are some of the main reasons people visit the garden.	✓
		Tourism	As the garden hosts a range of public activities it attracts both international and local visitors. The garden is a well-known eco-tourism destination in South Africa.	✓
	Habitat & supporting	Habitats for species	The garden serves an important role as "home" and refuge to a range of threatened and endemic fauna and flora species. The garden lies adjacent to other natural habitats such as Table Mountain National Park, creating a linkage and a biodiversity movement corridor for animals.	✓
		Genetic diversity	Display plants from all over South Africa, 2000 species are listed as threatened, that includes trees, shrubs, and medicinal plants. An abundance of indigenous birds and mammals are also found within the garden.	✓

Source: Hitchcock (2006); Willis and Morkel (2008); Titus and Spencer (2015).

6.4.4.3 Assessment of the green sport facilities best practice example

As part of the several ecological studies conducted in Potchefstroom, the study of Cilliers and Cilliers (2015) considered the use and benefits (ESs) of a sports field in Potchefstroom, South Africa, referred to as "Heilige Akker", as well as the Grimbeek Park Golf course. By utilising the data from the study of Cilliers and Cilliers (2015), as well as the direct observation made, the following ESs were recognised to a South African green sports facility best practice example. The ESs recognised within the Grimbeek Park Golf course and Heilige Akker sports ground are illustrated in **Table 6-17**.

Table 6-17: Self-assessment of the ESs generated by the Grimbeek Park Golf course and Heilige Akker sport grounds.

Heilige Akker sport grounds.

GOLF COURSE AND OTHER GREEN SPORT FACILITY (SPORTS FIELDS)				
Grimbeek Park Golf course and Heilige Akker sport ground				Physical location
				Potchefstroom, South Africa
				Location within the city
				-
				Access
				Public
				Initiated
				-
Source: Potchefstroom Country Club.				
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	The Mooi River runs through the golf course. Contribute to flow, storage, and purification of water.	✓
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	On a small scale provide local climate regulation through the vegetation and tree cover contributing to the cooling effect. Ultimately, sport fields add to the network of GI elements that together provides local climate regulation.	✓
		Air Purification	On a small scale provide local air purification through the vegetation, tree cover that acts as carbon storages, but ultimately add to the network of GI elements that together provides air purification for the urban area	✓
		Moderation of Extremes	Absorption function of the vegetation (lawns) offers the special function of the natural uptake of storm water preventing flood hazard while recharging groundwater sources.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	One of the main ESs provided by the particular GI elements. The GI element functions as a recreational facility offering people the opportunity to spend time outdoors, to play sport and relax.	✓
		Aesthetic contribution	Adds to greening the urban area.	✓
		Spiritual experience and sense of place	N.A.	✗
		Tourism	Seeing the recreational activities, the GI element attracts various visitors.	✓
	Habitat & supporting	Habitats for species	N.A.	✗
		Genetic diversity	As mentioned earlier the Mooi River runs through the golf course and includes various plant and animal species.	✓

Source: Own construction based on Cilliers and Cilliers (2015) and personal observations.

6.4.4.4 Assessment of the health clinic garden best practice example

The idea of ESs and best practice health clinics in South Africa was explored by Muller (2019). The study of Muller (2019) investigated existing ESs within 32 health clinic gardens in the North-West Province and Northern Cape Province, South Africa. Based on ecological surveys on the ESs recognised within the different health clinic gardens, the Jan Kempdorp health clinic garden was rated as the one the clinics with the highest ecological and socio-cultural values (ESs). Ultimately, the Jan Kempdorp health clinic garden and the results obtained by Muller (2019) was utilised as best practice examples to assess the ESs generated by a South African health garden. The ESs recognised within the Jan Kempdorp community health centre garden is illustrated in **Table 6-18**.

Table 6-18: Self-assessment of the ESs generated by the Jan Kempdorp community health centre garden.

centre garden.

HEALTH CLINIC GARDEN

The Jan Kempdorp community health centre garden



Physical location

Jan Kempdorp,
South Africa

Location within the city

Community health centre

Access

Public

Initiated

-

Source: Own construction (2020).

CRITERIA	Provisioning	Food supply	A relatively small vegetation garden, but produces 2.9930 kg/m ² of fruit and vegetables p/a. Some indigenous species utilised as food.	✓
		Raw materials	Both exotic and indigenous raw material species (26 different species) recognised within the health clinic garden.	✓
		Fresh water	N.A.	✗
		Medicinal resource	Both exotic and indigenous medicinal plant species were found within the health clinic garden.	✓
	Regulating	Local climate regulation	The garden has high tree cover (2536.9m ²) contributing to tree-shading, intercepting solar radiation, and absorbing heat	✓
		Air Purification	Wood plant species (120 trees) found within the garden contributes to high carbon storage. The 9620.8m ² of trees in the garden stores approximately 160 000 kg of sequestered carbon.	✓
		Moderation of Extremes	N.A.	✗
		Waste-water treatment	N.A.	✗

	Cultural	Recreation and cognitive development	Provides benches where people could sit.	✓
		Aesthetic contribution	The garden provides many potential ornamental plants species contributing to an aesthetical aspect.	✓
		Spiritual experience and sense of place	Some plant species recognised in the garden that could be utilised for potential spiritual or cultural values.	✓
		Tourism	N.A.	✗
	Habitat & supporting	Habitats for species	The garden includes a large natural area serving as habitat with food for indigenous organisms, plants, and animals. Approximately provides an area of more than 10 000m ² of habitat for plants and animals, including a habitat for bird species (nesting) and plant species attracting birds.	✓
		Genetic diversity	High number of species and vegetable cultivars recognised within the garden (63 species) – 28 indigenous species	✓

Source: Own construction based on Muller (2019).

6.4.5 Investigation into the ESs provision capacity of private green spaces

The chosen best practice example for a private home garden is the example of home gardens in Cosmo City, Johannesburg discussed by Adegun (2018a). Cosmo City is an 1150 Hectare Integrated Human Settlement housing project planned to accommodate households from informal settlements. Private home gardens within Cosmo city ranges in different forms and sizes. The home gardens provide a best practice example of home gardens and the ESs generated from the gardens within a lower-income urban community in South Africa. **Table 6-19** illustrates the ESs recognised by Adegun (2018a) within Cosmo City home gardens.

Table 6-19: Self-assessment of the ESs generated by the private home gardens in Cosmo city.

PRIVATE HOME GARDENS				
		Private home gardens in Cosmo city, Johannesburg		
		Physical location		
		Johannesburg, South Africa		
		Location within the city		
		Cosmo City, Integrated Human Settlement		
		Access		
		Private		
		Initiated		
		-		
CRITERIA	Provisioning	Food supply	Food production takes place within the gardens, including the production of vegetables such as tomatoes, spinach, pumpkins.	✓
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	Some plants cultivated in the gardens are utilised for indoor fragrance or medicine.	✓

Source: Adegun (2018a).

	Regulating	Local climate regulation	Shading of trees and other vegetation within the gardens (lawns and other plant species) has a sustainable contribution to a local cooling effect and overall aiding the network of GI elements that together mitigate the urban heat island effect and provides local climate regulation.	✓
		Air Purification	Multiple plant species (both vegetation and trees) has important carbon sequestration functions.	✓
		Moderation of Extremes	Locally contributes to directly capturing rainwater, rather than storm water run-off, therefore preventing flooding.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	Practicing horticulture are a relaxing activity and imparts gardening skills.	✓
		Aesthetic contributions	Gardens are landscaped and planted with lawns and ornamental flowers contributing to aesthetics.	✓
		Spiritual experience and sense of place	Gardening and their aesthetic aspects serve as self-expression and creates a sense of place which contributes to a persons' psychological well-being	✓
		Tourism	N.A.	✗
	Habitat & supporting	Habitats for species	Gardens are "biodiversity friendly" areas providing important habitat opportunities for species in urban areas.	✓
		Genetic diversity	A high diversity of plant species and cultivars is found in home gardens resulting in a high species diversity.	✓

Source: Own construction based on Adegun (2018a).

6.4.6 Investigation into the ESs provision capacity of informal green spaces

As previously mentioned in section 6.3.1, documented case-studies, and or data regarding the ESs generated by informal green spaces are lacking in a South African context. Therefore, the informal green spaces GI elements, 1) riverbank greenery, 2) roadside or railway verged greenery, and 3) vacant land examples and the ESs generated by these examples were assessed according to the directed observations made by the researcher. The results are accordingly discussed.

6.4.6.1 Assessment of the riverbank greenery best practice example

Similar to the assessment of the green sport facilities best practice example, the chosen riverbank greenery best practice example, Oewersig riverbank front, was also studied by Cilliers and Cilliers (2015) regarding the use and benefits (ESs) of the riverbank. The Oewersig riverbank green space is located in Potchefstroom, South Africa, on the banks of the Mooi River, flowing through Potchefstroom. By utilising the data obtained from the study of Cilliers and Cilliers (2015), as well as directed observation made by the researcher, the following ESs were recognised within the Oewersig riverbank green space and are illustrated in **Table 6-20**.

Table 6-20: Self-assessment of the ESs generated by the Oewersig Riverbank green space.

Table 6: LCI self-assessment of the LCC generated by the Oewersig Riverbank green space

RIVERBANK GREENERY				
			Oewersig Riverbank green space	
			Physical location	
			Potchefstroom, South Africa	
			Location within the city	
			Mooi River riverbank	
			Access	
			Public	
Initiated				
-				
Source: Own construction (2020).				

CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	Raw materials, such as wood and other biological materials are delivered and could be consumed as material.	✓
		Fresh water	The Mooi River contribute to flow, storage, and purification of water.	✓
		Medicinal resource	Indigenous plant species found within the area provide natural resources for traditional healers.	✓
	Regulating	Local climate regulation	Sustainable contribution to the mitigation of the urban heat island. The tree-shading, intercepting solar radiation, and absorbing heat. Other vegetation, tree cover and water features contribute to the cooling effect. Ultimately, the space adds to the network of GI elements that together provide local climate regulation.	✓
		Air Purification	The vegetation within the space contributes to high carbon storage and local air purification.	✓
		Moderation of Extremes	Floods could be mitigated through the space by reducing surface run-off, accumulating high levels of water, and absorbing the storm water back into the ground and Mooi River.	✓
		Waste-water treatment	The riverbank vegetation and soil have the ability to improve water quality by filtrating out, decomposing, and retaining nutrient pollutants and other organic wastes within storm water run-off before flowing into the Mooi River.	✓
	Cultural	Recreation and cognitive development	Provides a walking trail, as well as the opportunity to have a picnic or play outdoor games. Visitors could also do activities such as bird watching.	✓
		Aesthetic contributions	Contributes to an appealing and scenic natural beauty within the neighbourhood.	✓
		Spiritual experience and sense of place	Provides visitors with a peaceful and safe place in the natural environment for relaxation and meditation.	✓
		Tourism	Small eco-tourism space, providing the opportunity to enjoy the scenery and to learn and experience the local ecology of the Mooi River green space area.	✓
	Habitat & supporting	Habitats for species	Important shelter and nesting habitat for birds and plants and organism species.	✓
		Genetic diversity	N.A.	✗

Source: Own construction based on Cilliers and Cilliers (2015) and personal observations.

6.4.6.2 Assessment of the roadside or railway verged greenery best practice example

A best practice example of a roadside verged greenery on the Brakfontein road, Pretoria (South Africa) was directly observed by the researcher. The chosen best practice example provided an excellent local example of how an ordinary roadside parcel (grey infrastructure) could be replaced with green resources (natural vegetation) to contribute aesthetic elements and other ecological functions. The ESs observed and recognised within the roadside verged greenery are illustrated in **Table 6-21**.

Table 6-21: Self-assessment of the ESs generated by the roadside verge.

ROADSIDE OR RAILWAY GREENERY				
Roadside greenery on Brakfontein road (Pretoria) 			Physical location	
			Pretoria, South Africa	
			Location within the city	
			Brakfontein road, Midstream estate	
			Access	
			Public	
			Initiated	
Source: Own construction (2020).			-	
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	N.A.	✗
		Air Purification	N.A.	✗
		Moderation of Extremes	Captures some rainwater and filtrates it back into the ground, rather than to let the water flow and flood in the road area.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	N.A.	✗
		Aesthetic contributions	The main ecosystem services of the roadside verge are creating an aesthetic pleasing image, bringing nature into the mainly “grey” road area, capturing road user’s attention.	✓
		Spiritual experience and sense of place	N.A.	✗
		Tourism	N.A.	✗
Habitat	Habitats for species	Road verges are definitely good habitats for various species – plants, insects, reptiles.	✓	
	Genetic diversity	Different cultivars of plant species used for plantings of the verge.	✓	

Source: Own construction (2020) and personal observations.

6.4.6.3 Assessment of the vacant land best practice example

Table 6-22 provides an example of an urban vacant land and the ESs observed and recognised within the vacant land.

Table 6-22: Self-assessment of the ESs generated by a vacant land.

VACANT LAND				
			Physical location	
			-	
			Location within urban space	
			-	
			Privacy	
			-	
			Initiated	
			-	
CRITERIA	Provisioning	Food supply	N.A.	✗
		Raw materials	N.A.	✗
		Fresh water	N.A.	✗
		Medicinal resource	N.A.	✗
	Regulating	Local climate regulation	Trees and other natural vegetation on the vacant land could reduce air temperature, mitigating the local urban heat island effect.	✓
		Air Purification	Trees on the vacant land could contribute to removing air pollutants.	✓
		Moderation of Extremes	Captures some rainwater and filtrates it back into the ground, rather than let a flow and flood in the road area.	✓
		Waste-water treatment	N.A.	✗
	Cultural	Recreation and cognitive development	N.A.	✗
		Aesthetical	N.A.	✗
		Spiritual experience and sense of place	N.A.	✗
		Tourism	N.A.	✗
	Habitat	Habitats for species	N.A.	✗
		Genetic diversity	N.A.	✗

Source: Own construction (2020) and personal observations.

The following section of the empirical investigation reports on the findings from the first part of the exploratory case-study investigation.

6.4.7 Summary of the results

Table 6-23 summarised the “provision capacity” or the total ESs generated by each self-assessed best practice example in terms of GI elements. It was obvious from the self-assessment in the previous sections that each GI element generates several ESs simultaneously.

Table 6-23: Summary of findings on the self-assessed GI elements and the ecosystem services generated by the best practice examples.			TABLE KEY		CRITERIA: ECOSYSTEM SERVICES	PROVISIONING				REGULATING				CULTURAL				HABITAT	
			●	Generated by the element		Food supply	Raw materials	Fresh water	Medicinal resources	Local climate regulation	Air Purification	Moderation of Environment	Waste-water treatment	Recreation and Cognitive	Aesthetical	Religion, spiritual and symbolism	Tourism	Habitats for species	Maintenance of genetic diversity
SELF-ASSESSED BEST PRACTICE EXAMPLES	Grey-green designed elements	Green roof	●			●	●		●	●	●	●	●	●	●	●	●	●	●
		Green wall								●	●			●	●	●	●	●	●
		Sustainable urban drainage systems (constructed wetland)						●		●	●	●	●	●	●	●	●	●	●
		Sustainable urban drainage systems (rain garden)						●		●	●	●	●	●	●		●	●	●
	Urban agriculture	Community garden	●			●			●	●	●			●		●	●	●	
		Rooftop farming	●	●		●			●	●	●	●	●	●	●	●	●	●	●
		Horticulture	●			●			●	●	●	●	●	●	●	●		●	
	Urban natural remnants	Urban forest	●			●			●	●	●	●	●	●	●	●	●	●	●
		Existing or remnant natural areas								●	●	●	●	●	●	●	●	●	●
		Urban wetland	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●
		Urban river or stream						●		●	●	●	●	●	●	●	●	●	●
	Public green space	Urban park and child-friendly space						●		●	●		●	●	●	●	●	●	●
		Botanical garden						●	●	●	●			●	●	●	●	●	●
		Green sport facilities						●		●	●			●	●		●		●
		Health clinic garden	●	●		●			●	●	●			●	●	●		●	●
		Private home gardens	●	●		●			●	●	●			●	●	●		●	●
	Informal green spaces	Riverbank greenery		●	●	●	●		●	●	●	●	●	●	●	●	●	●	●
		Roadside or railway verged greenery										●			●			●	●
		Vacant land								●	●	●	●						

Source: Own construction (2020).

Illustrated in **Table 6-23** it is evident that from all of the assessed examples of GI elements identified some form of regulating services, especially local climate regulation and air purification, as well as providing cultural services were ESs mostly recognised. Most GI elements also contribute to recreational activities or the aesthetic value of an urban area. The majority of GI elements also generated habitat and supporting ESs that are important for the production of other ESs. The least recognised ESs were those of the provisioning category and could indicate that if a need for provisioning ESs is identified, specific GI elements should be planned for, for instance, a concentration on providing more urban agricultural GI elements.

While some of the individual values of the services provided by a particular GI element might be small, the potential significance lies within the total value of the GI element to provide a variety of ESs. For instance, the wetland GI element seems to be valuable since it contributes to all the ESs. This is also in line with the findings in the literature investigation of Bolund and Hunhammar (1999), De Groot *et al.* (2002), Gómez-Baggethun and Barton (2013), and Pfab *et al.* (2017:10). The results of the empirical investigation further support findings of the literature investigation regarding the need to consider and enhance the planning, protection, and preservation of natural remnants in urban areas. Along with the wetlands example, the other asset natural remnant GI elements (urban forest; existing or remnant natural areas e.g., nature reserves and urban river or stream) all indicated significant ESs provision and are considered as quality green spaces within their particular urban areas.

Another crucial finding was the significant number of ESs generated by gardens, including the community garden example, the horticultural garden example, the private home garden, and the health clinic garden examples. These GI elements were of the few GI elements that generate provisioning ESs. As was also indicated by Cilliers *et al.* (2018), this exploratory case-study results highlight the importance of considering all gardens as an important part of GI elements for providing important ESs and overall contributions to the quality of life in urban areas.

The above-identified results form part of the empirical investigation conclusion that will be further discussed in section 6.6. As discussed in the methodology section (c.f. 6.3) the following section further investigates the best practice examples of GI elements by assessing and analysing the multi-functionality of the different GI elements.

6.5 Phase 2 - Data analysis of the multi-functionality of the different GI elements

In contrast, with the assessment of the previous section on the numerous ESs the GI elements could generate simultaneously, Hölting *et al.* (2019:124083) stresses in the literature investigation (c.f. 5.4.3.2) to bear in mind that multi-functionality is not solely “the more ESs the better”, but

multi-functionality rather depends on the numerous ESs categories (provisional, cultural, regulating, and habitat & supporting services) recognised within the GI element. Based on the results gathered in the first phase of the assessment, the following section attempts to self-assess the level of ESs recognised within the four ES categories, to determine the level of multi-functionality for each GI element. As discussed in section 6.3.2 (Data analysis through self-assessment) the assessment of the GI elements is completed based on **Table 6-3** and **Table 6-4**. The results of the self-assessment are illustrated in the following table (**Table 6-24**).

Table 6-24: The self-assessment of the multi-functionality of the different best practice example GI elements.

	GI ELEMENTS	PROVISIONAL	REGULATION	CULTURAL	HABITAT & SUPPORTING	MULTI-FUNCTIONALITY LEVEL
Grey-green designed elements	Green roof	2	3	3	3	Medium
	Green wall	0	2	3	3	Low
	Sustainable urban drainage systems (constructed wetland)	1	3	3	3	Medium
	Sustainable urban drainage systems (rain garden)	1	3	3	3	Medium
Urban agriculture	Community garden	2	2	3	3	Low
	Rooftop farming	2	3	3	3	Medium
	Horticulture	2	3	3	2	Low
Urban natural remnants	Urban forest	2	3	3	3	Medium
	Existing or remnant natural areas	0	3	3	3	Medium
	Urban wetland	3	3	3	3	High
	Urban river or stream	1	3	3	3	Medium
Public green space	Urban park and child-friendly space	1	3	3	3	Medium
	Botanical garden	2	3	3	3	Medium
	Green sport facilities	1	3	3	0	Low
	Health clinic garden	3	2	3	3	Medium
	Private home gardens	3	3	3	3	High
Informal green spaces	Cemeteries or burial grounds	0	2	1	0	Mono-functional
	Riverbank greenery	3	3	3	3	High

GI ELEMENTS		PROVISIONAL	REGULATION	CULTURAL	HABITAT & SUPPORTING	MULTI-FUNCTIONALITY LEVEL
	Roadside or railway verged greenery	0	1	1	3	Mono-functional
	Vacant land	0	3	0	0	Mono-functional

Source: Own construction (2020).

It is apparent from **Table 6-24** that two groups of GI elements especially indicated high levels of multi-functionality, namely the green roof and the sustainable urban drainage system grey-green designed elements, as well as the urban-natural remnants. The majority of the multi-functionality levels of the GI elements ranged between medium and high multi-functionality. Other elements such as rooftop farming, the urban park, and child-friendly space, botanical garden, and riverbank greenery also confirmed a medium multi-functionality level. Assessing the levels of multi-functionality indicating overall that GI elements are multi-functional, providing more than one function and could serve in a variety of needs within one space. Elements such as the urban wetland and private home garden best practice examples indicated a significant number of ESs (c.f. **Table 6-23**) also confirmed a high level of multi-functionality. These results form part of the empirical investigation conclusions, which will be further discussed in the following section.

6.6 Conclusions regarding the exploratory case-study investigation

The literature investigation identified planning for GI a resourceful and effective way to promote multi-functionality (Madureira & Andresen, 2013:39) and effectively integrate multiple ESs into urban planning. In an attempt to qualitatively explore the “phenomena” (ecological aspects and concepts of ecosystem services and multi-functionality) within a South African context, best practice example (case studies) GI elements were self-assessed in terms of the ESs they generate, as well as their level of multi-functionality. The investigation identified potential best practice examples of multi-functional GI elements within the South African context. From the findings of the empirical investigation (c.f. **Table 6-23** and **Table 6-24**) it is apparent that GI elements present the capability to deliver numerous ESs within limited space. Some GI elements, specifically the informal green spaces indicated fewer ESs and had a low level of multi-functionality, however, should not be overlooked by urban planners as these spaces serve as an

important link between other elements, that together could contribute to landscape multi-functionality (c.f. literature investigation section 5.4.2). It should, however, be remembered that the self-assessed best practice examples of GI elements and their ESs are case-specific and context-based. Some GI elements could have generated other ESs, depending on their context and implementation, for instance, the green wall discussed in section **6.4.1.2** did not supply food, and however, some green walls could be implemented to grow food.

Nevertheless, the findings of the empirical investigation concur with the findings in the literature investigation, that ESs endorse multi-functionality. These findings invoke a meaningful link between the ecological considerations of ecosystem services (urban ecological knowledge) and planning through considering the GI multi-functionality principle. For the GI multi-functionality principle to be fully appreciated and valued would require further clarification and an increased awareness-making of ESs and multi-functionality amongst urban planners. Therefore, the following component of the empirical investigation chapter (Chapter 7) set out to capture the general knowledge and considerations among South African urban planners regarding ecosystem services, green infrastructure planning, and multi-functionality (ecological considerations), within an “applied setting” namely South African urban planning practice.

CHAPTER 7 – GATHERING EMPIRICAL EVIDENCE ON SOUTH AFRICAN URBAN PLANNERS’ KNOWLEDGE AND CONSIDERATIONS TO ECOLOGICAL ASPECTS AND CONCEPTS

7.1 Structure of the Chapter

Figure 7-1 illustrates the structure for Chapter 7.

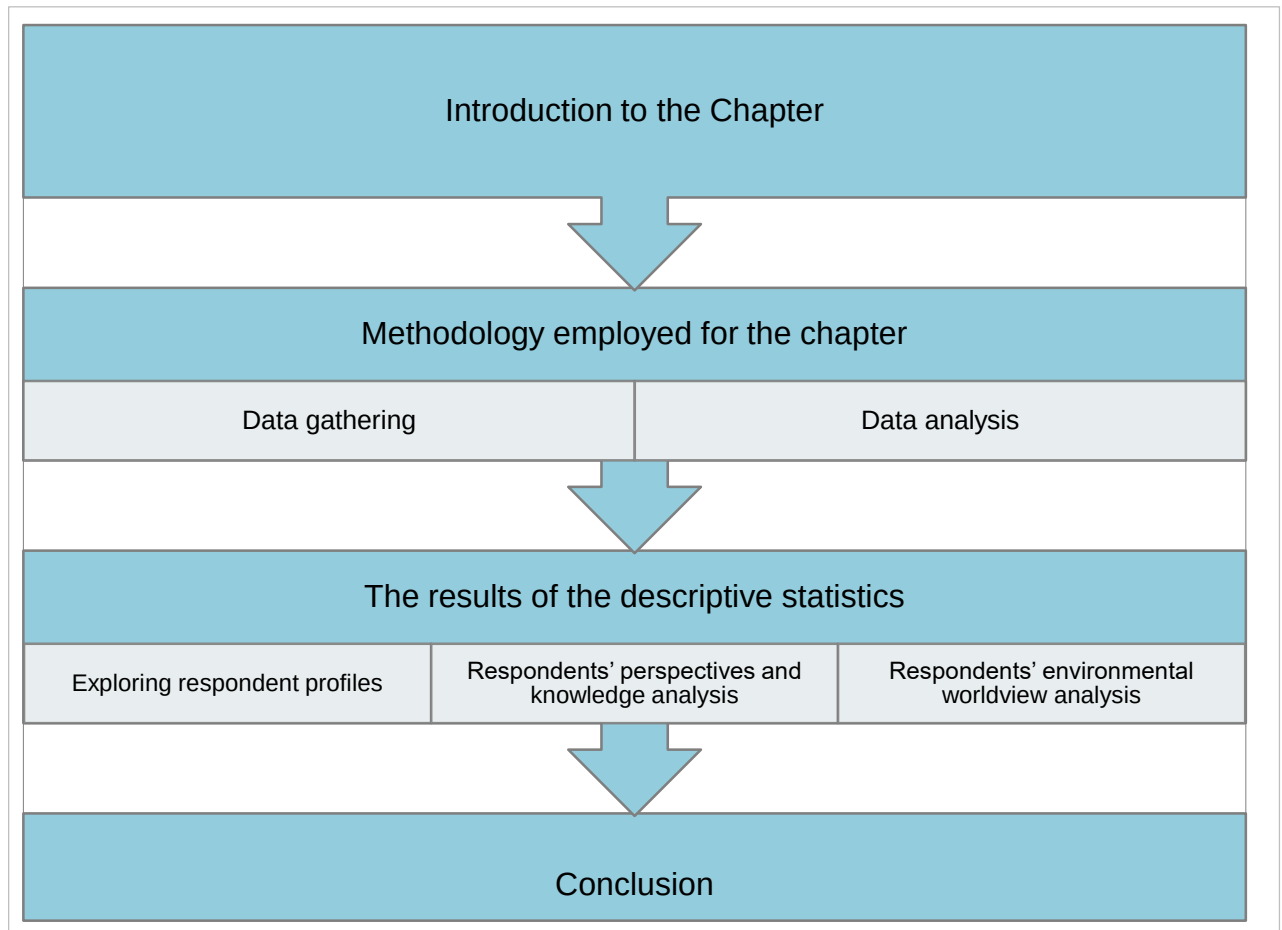


Figure 7-1: The structure of Chapter 7.

Source: Own construction (2020).

7.2 Introduction to the Chapter

Chapter 7 employs the second component of the embedded mixed-method investigation. Kohlbacher (2006) recommends when conducting an exploratory case-study investigation (such as conducted in the previous empirical investigation chapter, Chapter 6) to further building on the exploration by employing “survey-based research”.

Consequently, by employing a survey-based research approach, this chapter gathers and analyses quantitative data as a supporting role to build on the exploratory case study investigation

(Chapter 6) to investigate the ecological aspects and concepts of ecosystem services (ESs), green infrastructure (GI) planning, and multi-functionality (the “phenomena”) within in an “applied setting”, namely South African urban planning practice.

The following section elaborate on the research methods (data gathering and analysis) employed, and reports and discusses the results obtained following data analysis, in line with the chapters aim.

7.3 Methodology employed for empirical investigation: PART B.

Part B of the empirical investigation employed survey-based research. Survey-based research is defined as the collection of information from individual respondents through enquiring questions (Ponto, 2015:168). Both qualitative and quantitative research methods could be employed in survey-based research (Ponto, 2015:168). A quantitative research method (data gathering and analysis) was employed for this dissertation’s survey-based research. Surveys are well-known to be conducted to gather quantitative information to explore or describe a certain phenomenon through statistical analysis (Maree, 2020:193). This implies the survey to be grounded in questions with numerical rating items (Ponto, 2015:168) and to gather data that is quantifiable and statistically presented (Maccallum *et al.*, 2019:35).

According to Farthing (2016:127), surveys are an in-depth data gathering approach that is well established in urban planning research and is familiar to planners. Planning researchers tend to employ quantitative research methods to gather data describing characteristics or general phenomena associated with a population (Maccallum *et al.*, 2019:35). A “population” refers to the entire entity or collection one seeks a phenomenon to be investigated in (Salkind, 2010) for example a group of people or entities such as organisations (Maccallum *et al.*, 2019:35). The population of interest for this dissertation is South African urban planners.

The survey-based research was employed in this dissertation to reach a better understanding of South African urban planning practice regarding 1) the ecological aspects and concepts of GI planning, ecosystem services, and multi-functionality among South African planners, 2) the current state of integration and implementation of such aspects and concepts in South African urban planning practice. Furthermore, survey-based research is suggested as an appropriate approach to draw comparisons (Maree, 2020:196). The survey furthermore aimed to determine the environmental worldview among respondents as South African urban planners and the relation to considering ecological aspects and concepts in South African urban planning practice.

In survey-based research, researchers comply a set of structured questions to be administrated with a predetermined subset or sample of respondents that represent the target population (Burns

& Bush, 2014:146). Subsequently, the following sections describe the research methods utilised in the survey.

7.3.1 Data gathering

The data gathering method employed for the survey was an electronic questionnaire disseminated online. Online surveys are known to be conventional data gathering methods which could be easily distributed to the target survey population (Ponto, 2015:168).

Farthing (2016:201) emphasises that it is important to bear in mind that planning differs in different countries in terms of contextual and practical aspects. Accordingly, Farthing (2016:201) recommends local planning practitioners as important data sources, with “specific-country-based knowledge” of the phenomena being investigated. Therefore, the population of interest for the particular survey-based research is South African urban planning practitioners registered as Planners at the South African Council for Planners (SACPLAN). From this population, the researcher employed quantitative sampling in order to gather a sample of respondents to be included in the survey.

7.3.1.1 Quantitative sampling

The purpose of quantitative sampling is to gather a proportionate sample representing the target population (Ponto, 2015:168). A proportionate sample prevent the occurrence of generalisation of the survey results (Maccallum *et al.*, 2019:35).

Part B of the empirical investigation commenced with identifying participants based on the **purposive sampling** technique. According to Maree (2020:220) the purposive sampling technique is employed when the sample should meet a specific purpose. The “*purpose*” of the research sample was to include urban planning practitioners registered as Planners at the South African Council for Planners (SACPLAN). The sample of registered urban planning practitioners was gathered from the “SACPLAN Consultant Directory”, including a list of registered South African urban planning consultants (SACPLAN, 2019).

Each of these above-mentioned participants, as part of the purposively selected sample who agreed to participate in the survey, were then further asked to provide the e-mail address of a fellow urban planner they think would be willing to participate in the survey. This is referred to as a **snowball sampling** technique. The snowball sampling technique features contacting one or more participants of the intended population, who are then asked to identify other participants with the same characteristics who could be contacted next (Maree, 2020:220). An advantage of this particular technique is the fast distribution of the questionnaire to a variety of willing

participants (Farthing, 2016:88). An additional 82 new email addresses were gathered from the snowball sampling technique.

7.3.1.2 Structure of the questionnaire

The questionnaire commenced with a consent paragraph guaranteeing confidentiality and the anonymity of each participant. In the same line, the paragraph further stipulated the general research purpose, why the respondents were selected to participate, what is expected from the respondent in the survey, time commitments, and that the survey is completed on a voluntary basis. It was furthermore mentioned that ethical approval for the research was provided from The North West University's Faculty of Natural and Agricultural Sciences (FNAS) ethical committee (Ethics number: 01464 - 20 - A9). Refer to **Annexure One** for the complete questionnaire. The questionnaire then comprised of the following three main sections:

7.3.1.2.1 Section 1 – Demographic background data

The questions included in section 1 were related to the professional background of the respondents, including their sector of occupation, current professional (SACPLAN) registration, the year they obtained their undergraduate degree, as well as their years of planning experience.

7.3.1.2.2 Section 2- Ecological considerations data

Section 2 of the questionnaire determined the general understanding among planners regarding the ecological aspects and concepts of GI planning, multi-functionality, and ecosystem services (ESs), as well as the state of inclusion of these aspects and concepts in South African urban planning practice.

7.3.1.2.3 Section 3 - Environmental worldview data

Section 3 intended to determine the environmental worldview of urban planners by means of the revised New Ecological Paradigm Scale (NEP). The NEP was discussed in section 4.6.2 as a scale widely employed to measure the degree of a person's environmental attitude and behaviour (Moghimehfar, 2016:1; Ntanos *et al.*, 2019:239). The revised NEP-Scale consists of 15 questions where respondents were required to indicate their level of agreement with each question based on a Likert-scale (e.g., strongly agree, mildly agree, unsure, mildly disagree or strongly disagree) (Dunlap *et al.*, 2000:433) (refer to **Annexure One** for the complete 15-item questions).

Ultimately, the questionnaire comprised of 30 questions (both Likert-scale questions, as well as open-ended questions). The questionnaire was compiled using the internet-based programme "Google Forms" and was circulated digitally via electronic mail to the sample population.

7.3.2 Data analysis

The data obtained from the questionnaire was captured in electronic format and was transferred to Microsoft Excel, a programme platform that offers statistical analysis. The programme was utilised for the calculation and analysis of the gathered data for the descriptive discussion in section 7.4.

7.3.2.1 Data analysis of section 1 – Demographic background data

Question 1 (Please indicate your sector of employment) was asked to determine whether respondents' in the two different sectors of occupation (private or public) could indicate a variance in awareness and knowledge, and perceived level of integration of the ecological considerations (ecological aspects and concepts). **Question 2** (Which SACPLAN registration applies to you?) was similar to question 1, asked to determine whether different levels of registration could indicate a variance in awareness and knowledge, and perceived level of integration of the ecological considerations. **Question 3** (In which year did you receive your undergraduate degree) is related to the tertiary education of the respondents and aims to determine if more recent graduates tend to be more familiar with planning for ESs. **Question 4** (Please indicate your years of experience) was asked to determine a correlation between years of practical experience the respondents have and their perceived level of ESs integration.

7.3.2.2 Data analysis of section 2 - Ecological considerations data

For the first part of section 2, the questions were aimed at the concept of ESs (Question 5,6,7,8 and 9), thereafter, the questions were related to other ecological aspects and concepts such as urban ecology and GI planning (Questions 10, 11 and 12), and multi-functionality (Question 13). The findings of these sections were used to compare, build on or to further inform the findings of the literature investigation. As captured in **Table 7-1** the survey results were evaluated according to the four literature investigation chapters, (Chapters 2-4).

Table 7-1: Respondents' perspective and knowledge analysis delineation.

CONCEPTS OF AN ECOLOGICAL APPROACH	ECOSYSTEM SERVICES	URBAN ECOLOGY AND GREEN INFRASTRUCTURE	MULTI-FUNCTIONALITY
LITERATURE CHAPTER REFERENCE	Chapter 4	Chapter 2 & 3	Chapter 5
QUESTIONS	5, 7, 8, and 9	10, 11, and 12	13
MAIN THEMES OF THE QUESTIONS	- Question 5 (<i>How familiar are you with the concept of ecosystem services</i>) was asked to determine the opinion of South African urban planners' regarding their familiarity with the ESs concept. - Question 6 (<i>Please define ecosystem services to the best of your knowledge</i>) an open-ended question was asked, and the respondents had the opportunity to define ESs in their own words to provide some insight regarding their actual comprehension of the ESs concept. - Question 7 (<i>Please provide examples of ecosystem services</i>) further explores the respondents' comprehension of the ESs concept, as well as their recognition of different types and categories of ESs. A thematic analysis was employed for both Question 6 and 7 to organise the data and to capture valuable information and common perspectives among the respondents. - Question 8 (<i>How would you rank the importance of planning for ecosystem services</i>) determined the importance of considering ESs in current urban planning activities. - Question 9 (<i>How often do you consider ecosystem services in your planning activities</i>) determine the level of consideration of ESs in current urban planning activities.	- Question 10 was asked to determine if the concepts of urban ecology and GI planning are taken into consideration by respondents within their planning activities. - Question 11 (<i>Why did you take these concepts into consideration</i>) was asked to determine the motives behind considering the ecological aspects and concepts. - By enquiring Question 12, (<i>what challenges have you encountered in applying ecological concepts</i>) the challenges encountering the consideration and integration of these ecological aspects and concepts in South African urban planning practice was determined.	Question 13 focused on the multi-functionality concepts within urban planning practice (<i>Please indicate which one of the following phrases you consider as the best definition for the concept 'multi-functionality' of spaces</i>) and was asked to determine which definition of multi-functionality is more familiar to South African urban planning practitioners.

Source: Own construction (2020).

Data obtained from both Section 1 and Section 2, were analysed to determine frequencies within the responses. The data analysis of Section 3 of the questionnaire followed.

7.3.2.3 Data analysis of section 3 – Environmental worldview data

The 15 questions of the NEP-scale (Dunlap & Van Liere, 2008), that were employed in Section 3 of the questionnaire, are grounded on five dimensions of environmental thought, namely:

- 1) **Reality to limiting of growth (questions 14-1, 14-6 and 14-11):** the believes that the earth has limited resources and is concerned with the capacity of earth to accommodate the growing population (Erdoan, 2009:1027; Amburgey & Thoman, 2012:238).
- 2) **Anti- anthropocentrism (questions 14-2, 14- 7 and 14-112):** the believe that nature does not primarily exists for human use. The dimension enhances the statement that plants and animals have equal rights of existence to humans (Amburgey & Thoman, 2012:238).
- 3) **Vulnerability of nature's balance (questions 14- 3, 14-8 and 14-13):** the believe that human activities have negative consequences and influence the balance of nature (Amburgey & Thoman, 2012:238).
- 4) **Anti-exceptionalism (questions 14-4, 14-9 and 14-14):** the believe that human beings are not dominant and valued higher than other organisms in the natural environment (Hawcroft & Milfont, 2010:143; Ntanos et al., 2019:239).
- 5) **Possibility of an eco-crisis (questions 14-5, 14-10 and 14-15):** the believe that humans' dependence on the physical environment and their activities are causing harm to the environment (Amburgey & Thoman, 2012:238).

Colby and Mundial (1989:8) believe that the **ecocentric environmental worldview (pro-NEP)** indicates that humans recognise that they have an ethical responsibility toward protecting the environment through co-development and that they are a “part of nature, not apart from nature” (Washington *et al.*, 2017:35). An **anthropocentric environmental worldview (pro-DSP)** considers humans as independent from and valued higher than other organisms in the natural environment (Hawcroft & Milfont, 2010:143; Ntanos *et al.*, 2019:239) along with characteristics of endless progress and growth (Nooney *et al.*, 2003:764) and no explicit concerns regarding natural resource exhaustion (Colby & Mundial, 1989:8). Eight of the 15 -items (the odd numbered questions) are meant to reflect an ecocentric view (pro-NEP), while the seven other questions (the even numbered questions) represent an anthropocentric view or the endorsement of the DSP (Dunlap *et al.*, 2000:432; Anderson, 2012:260).

Based on the methodology of Wilhelm-Rechmann *et al.* (2014) each of the 15-items was measured on a scale ranging from 1 to 5. Odd numbered questions indicated a pro-NEP. All pro-NEP responses were expected have relatively high scores (out of 5) and responses were scored accordingly, 5=Agree; 4=mildly agree; 3=Neutral; 2=mildly disagree; and 1= Disagree. Even numbered question that reflected a pro-DSP stance and were inverted, therefore responses were scored as 1=Agree; 2=mildly agree; 3=Neutral; 4=mildly disagree; 5=Disagree. Pro-DSP responses were expected to have a relatively low score (out of 5) in order for respondents to have a pro-environmental worldview. Percentages and mean scores for the eight pro-NEP items and seven pro-DSP response based on the five-point scale were calculated to determine the overall mean rating of each of the 15- items. Thereafter, the results of the 15-items were utilised to calculate the average percentages of the five dimensions the 15-items are grounded on. An overall environmental worldview of South African urban planners was also determined out of a score of 75 (15-items equals the five-point scale) representing maximum ecocentric environmental worldview (pro-NEP). The approach employed here is based on the work of Wilhelm-Rechmann *et al.* (2014).

Additionally, to further analyse the data obtained, selected questions were cross tabulated to determine correlations. The methodology employed for cross-tabulation follows.

7.3.2.4 Cross-tabulation

Cross-tabulation includes a table representing the frequencies of two or more variables and the determination of a practical significant relationships between the variables (Steyn & Ellis, 2003:52).

Data from the following questions, as illustrated in **Figure 7-2**, were cross-tabulated and statistically represented and interpreted.

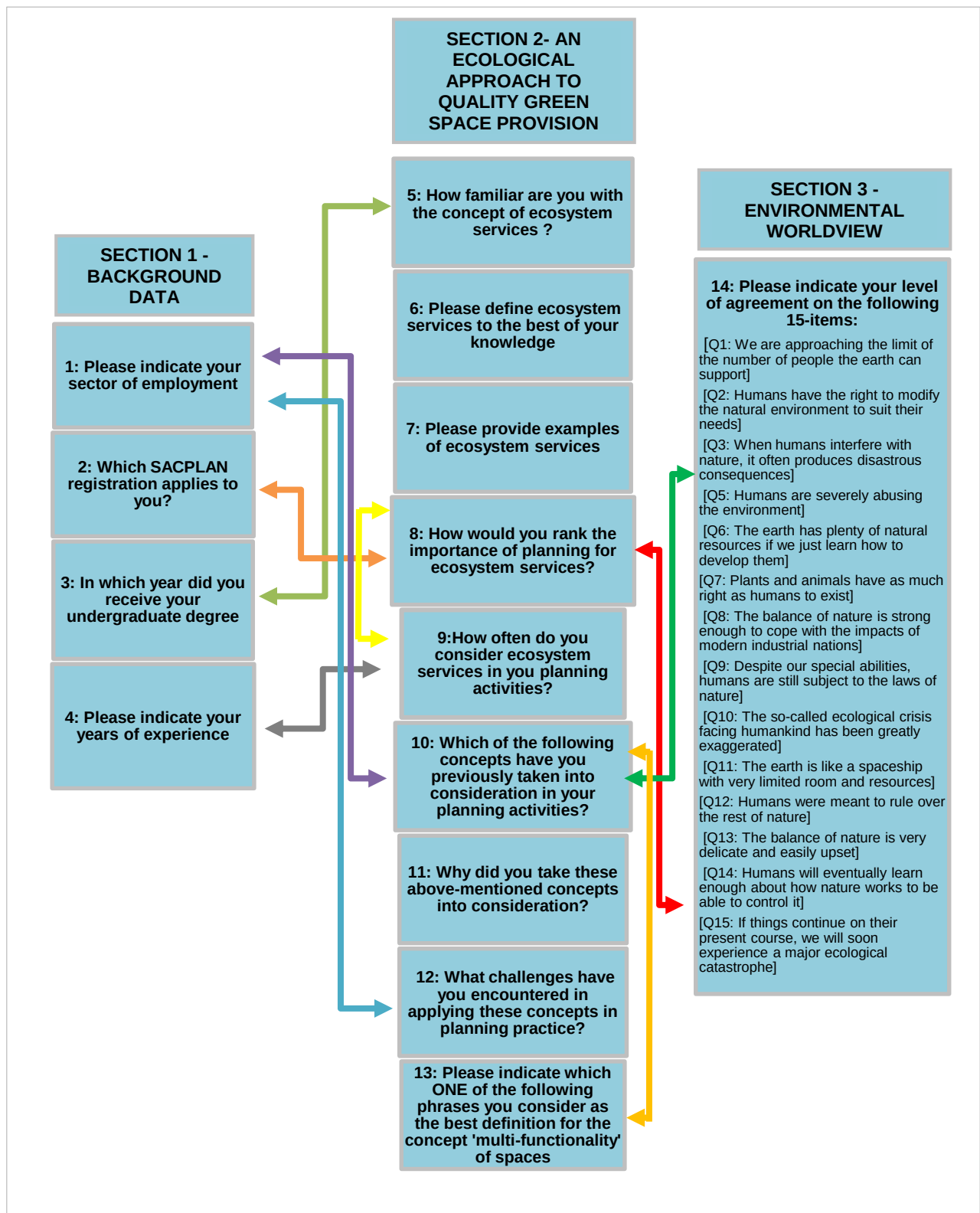


Figure 7-2: Cross-tabulation between questions.

Source: Own construction based on questionnaire results (2020).

The cross-tabulations were completed with the Cramer's V-test. According to Liebetrau (1983:782) a Cramer's V-test result of $V \sim 0$ represent no relationship between the variables. A Cramer's V-test of $V \sim 0.5$ represents a large effect or practical significance, while a V-test of $V \sim$

0.3 indicates a medium effect or practical visible significance. A Cramer's V-test results of $V \sim 0.1$ only represent a small effect or practical non-significance (Steyn & Ellis, 2003:52). A Cramer's V-test results of $V \sim 1$ represent the maximum correlation, ultimately, results closer to $V \sim 1$, would indicate a stronger correlation between the variables (Liebetrau, 1983:782).

7.4 The results of the descriptive statistics

Of the study population, a total of 42 respondents completed and returned the questionnaire. Data collected from the 42 responses were statistically analysed, presented, and discussed accordingly.

7.4.1 Exploring the demographic background data of the respondents

As discussed in a previous section, the first part of the questionnaire captured the demographic background of respondents as South African urban planners. The findings of the four demographic background questions are captured accordingly.

7.4.1.1 The main sector of occupation of the respondents

The respondent's sector of occupation is illustrated in **Figure 7-3**.

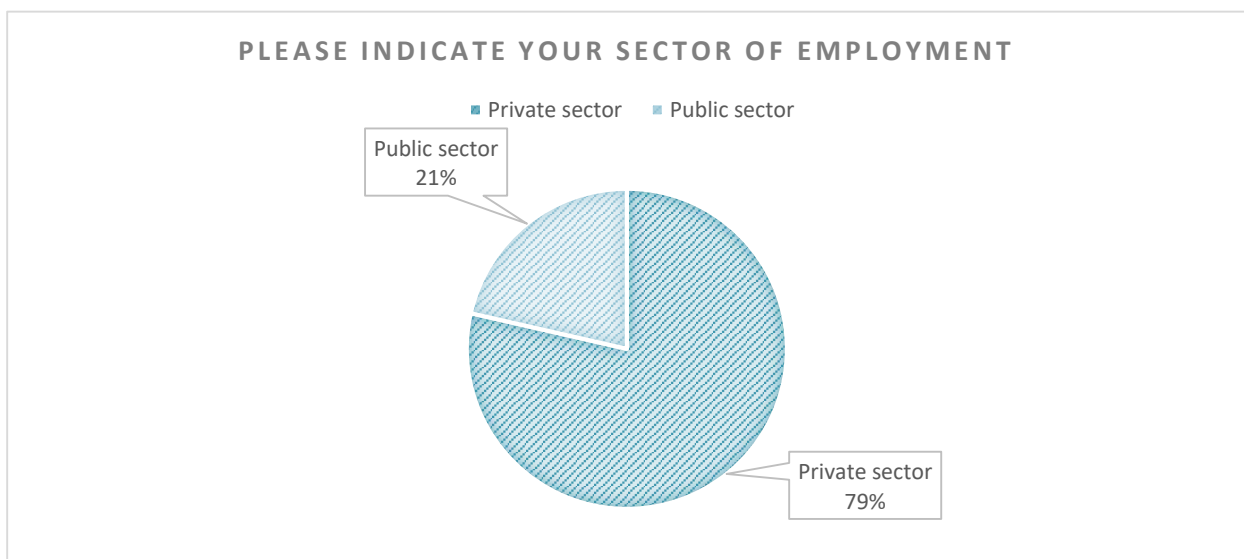


Figure 7-3: The sector of occupation of the respondents.

Figure 7-3 illustrates that 79% of the sample of 42 planners are employed in the private sector, while 21% of the respondents are employed in the public sector.

7.4.1.2 The professional planning registration of the respondents

Respondents had the opportunity to choose between three of SACPLAN's professional planning registration categories namely: 1) Technical planner; 2) Candidate planner; and 3) Professional planner. **Figure 7-4** illustrates that 86% of respondents indicated that they are registered as

Professional planners. In the view of this result, the views of these respondents could prove valuable to the study. Moreover, 14% respondents were registered as Candidate Planners. As indicated in **Figure 7-4**, no technical planners were found within the sample of urban planners.

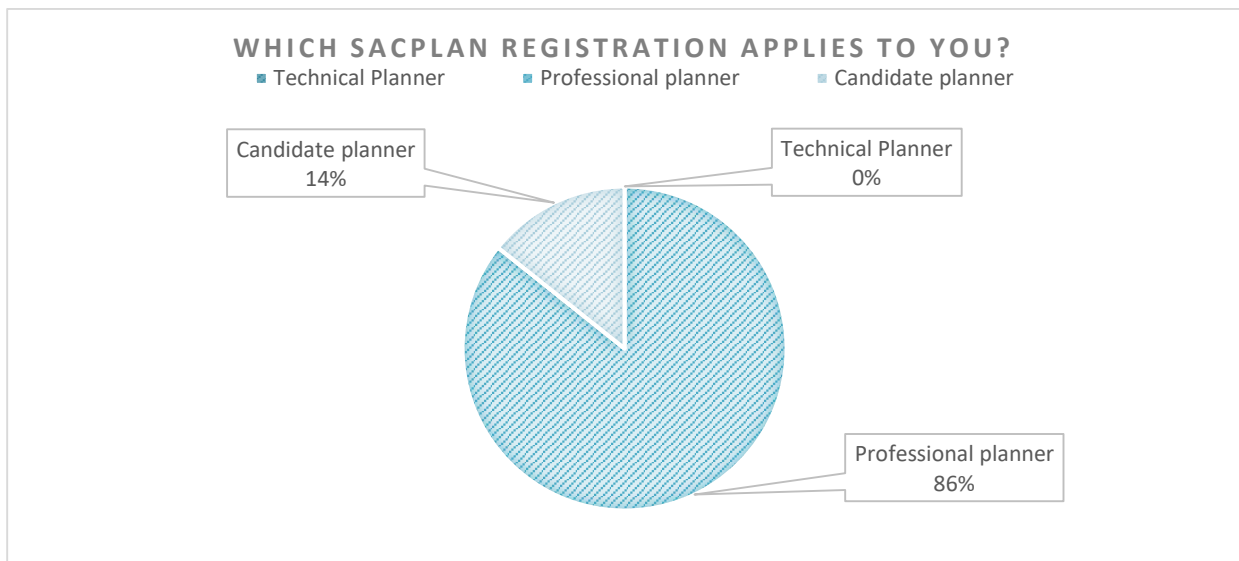


Figure 7-4: Professional (SACPLAN) registration categories applicable to the respondents.

7.4.1.3 The year in which the respondents received their undergraduate planning degree.

Forty-one percent (41%) of those urban planners surveyed indicated in Question 3 receiving their undergraduate planning degree after 2011. **Figure 7-5** illustrates approximately 26% of the respondents received their undergraduate degree before 1990.

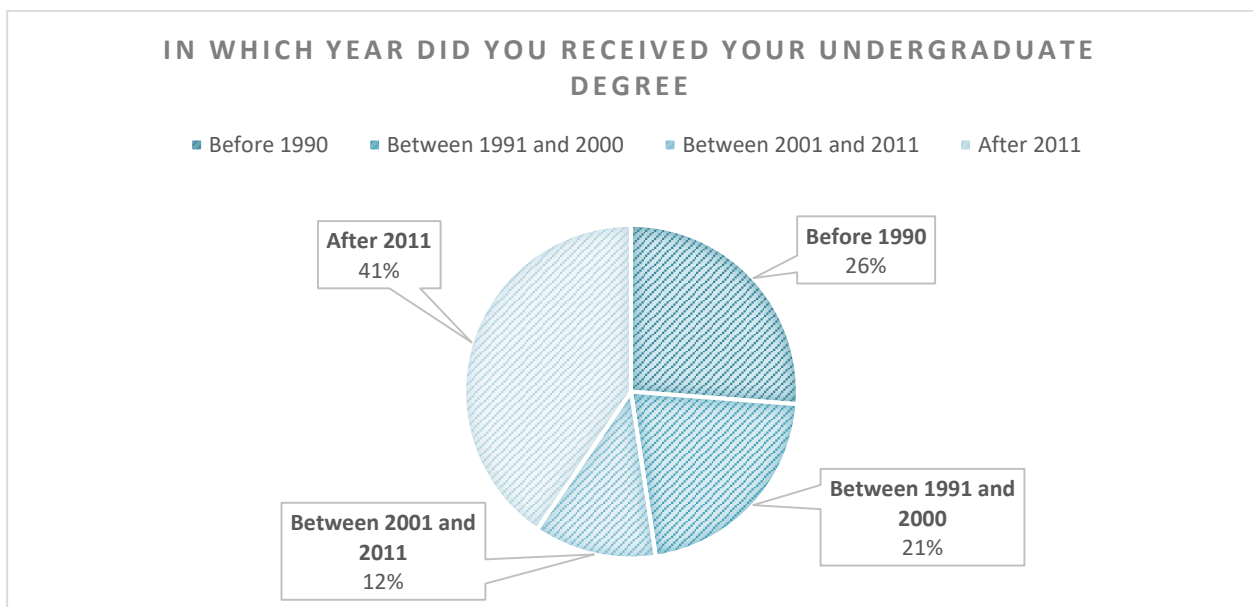


Figure 7-5: The year the respondents received their undergraduate planning degree.

7.4.1.4 The years of experience of the respondents

The years of experience of the sample of urban planners are illustrated below in **Figure 7-6**.

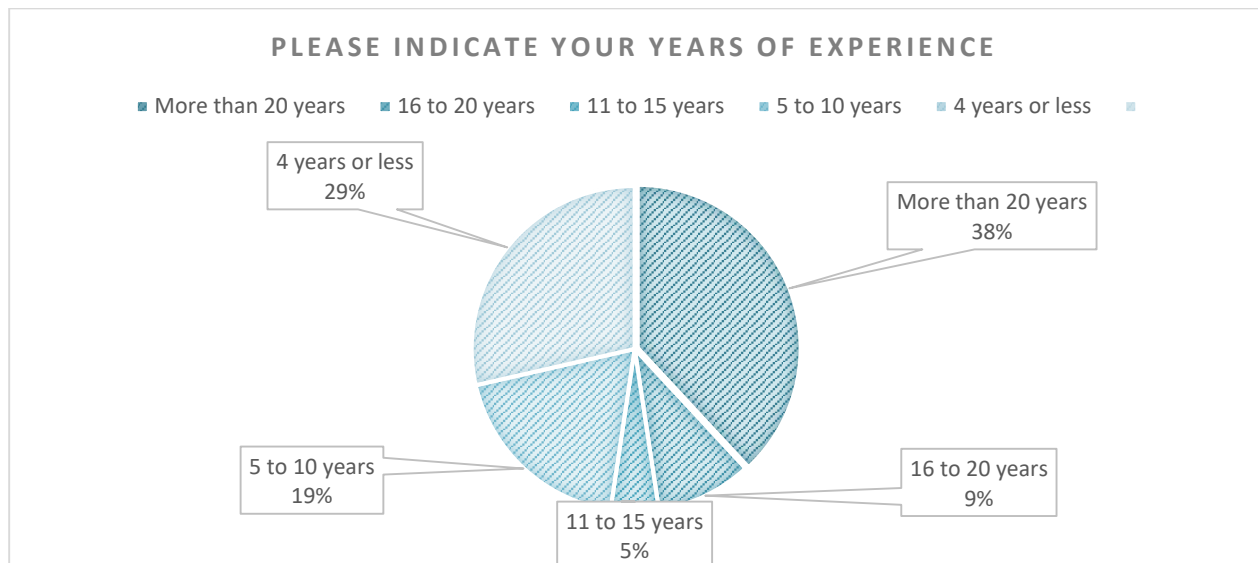


Figure 7-6: The years of experience of the respondents.

In response to Question 4, 38% of those surveyed indicated more than 20 years of practical urban planning experience. This plays an important role in trustworthiness of the results, as these respondents present many years of South African urban planning experience and would be well-acquainted with the planning activities being employed. Based on **Figure 7-6**, it could further be seen that the second highest category of years of experience was planners with 4 years or less experience (29%). The remaining categories included 16 to 20 years with 9% of the respondents, 11 to 15 years with 5%, and 5 to 10 years with 19%.

7.4.2 Exploring the data regarding ecological considerations of the respondents

According to Abass *et al.* (2019:2), “knowledge is the motive behind attitude, and it could be logically argued that knowledge or perceived knowledge of urban greenery could influence one’s attitude towards considering urban greenery”. Section 2 of the questionnaire therefore intended to capture the general knowledge and consideration among South African urban planners regarding aspects and concepts related to an ecological approach such as ESs, GI planning and multi-functionality. The findings are captured accordingly.

7.4.2.1 The respondents’ familiarity with the ecosystem services concept

As illustrated in **Figure 7-7**, approximately 40% of the 42 responses rank their familiarity with the ESs concept near “never heard of it before”. Approximately 10% of the respondents indicated that they are “very familiar” with the ESs concept. The majority of the respondents ranked their familiarity between “very familiar” and “never heard before” indicating a degree of un-familiarity of

the concept among South African urban planners. This result reflects findings presented in the literature investigation (c.f. 4.6), that stated that many planners worldwide are still sceptical and unfamiliar with the ESs concept (Albert *et al.*, 2014:1303; Steiner, 2016:108).

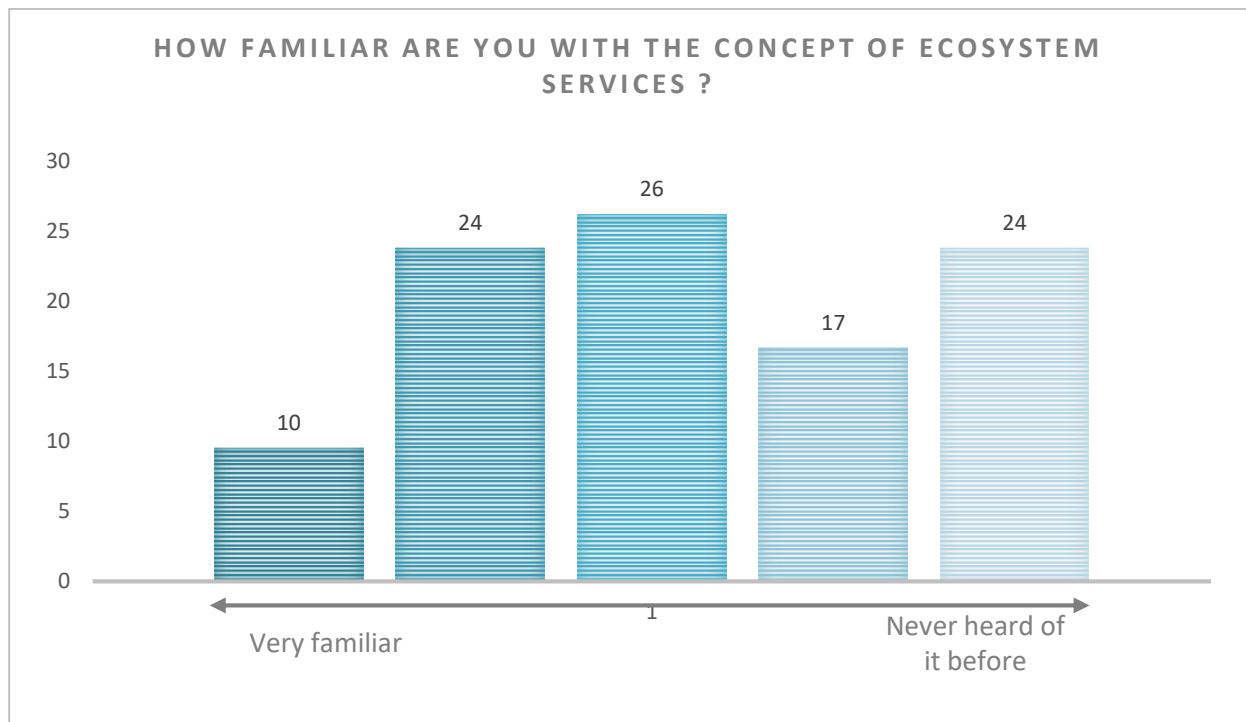


Figure 7-7: Respondents' familiarity with the ecosystem services concept.

The above-discussed question (Question 5) was cross-tabulated with Question 3 (In which year did you receive your undergraduate degree) in an attempt to determine if the year planners received their undergraduate degree could have an influence on their familiarity with the ESs concept (**Table 7-2**). For instance, if more recent graduates tend to be more familiar with the concept.

Table 7-2: The cross-tabulation between planners' familiarity with the ecosystem services concept and the year they have received their undergraduate degree.

Q5 WITH Q3	QUESTION 5: How familiar are you with the concept of ecosystem services?				
QUESTION 3: In which year did you receive your undergraduate degree	OPTIONS	VERY FAMILIAR	3	NEVER HEARD OF IT BEFORE	TOTAL
		1-2		4-5	
	1) Before 1990	6 (54.5%)	0 (0.0%)	5 (45.5%)	11 (100%)
	2) Between 1991 and 2000	2 (22.2%)	4 (44.4%)	3 (33.3%)	9 (100%)
	3) Between 2001 and 2011	1 (20%)	2 (40%)	2 (40%)	5 (100%)
	4) After 2011	5 (29.4%)	5 (29.4%)	7 (41.2%)	17 (100%)
	TOTAL	14 (33.3%)	11 (26.2%)	17 (40.5%)	42 (100%)

Pearson Chi-Square	Cramer's V-test	Cramer's V approximate significance
6.804	0.285	0.339

In **Table 7-2** a cross-tabulation detected a $V \sim 0.285$, illustrating only a medium effect between the variables. Therefore, no clear correlation was indicated between planners' familiarity with the ESs concept and the year they received their undergraduate degree. It was already clear in **Table 7-2** that 40% of the planners were not familiar with the concept, regardless of when they received their undergraduate degree.

7.4.2.2 The definition of ecosystem services provided by the respondents

The literature clearly emphasised the importance of investigating the views and knowledge of planning practitioners regarding the ESs concept (Niemelä *et al.*, 2010:3239; Mascarenhas *et al.*, 2014:1287; La Rosa, 2019:1). Question 6 asked an open-ended question, and the respondents had the opportunity to define ESs in their own words to provide some insight regarding their knowledge and comprehension of the ESs concept.

Each of the definitions provided by the respondents were subjectively ranked on a scale from 1-3 based on the similarity to the definition for ESs formulated in the literature investigation. The definition follows as:

"The benefits all living species (especially humans) derive, directly or indirectly, from the capacity (function) of ecosystems to provide goods and services that satisfy needs and human well-being." (c.f. Table 4-1).

A ranking of 1 was allocated if the respondents' definition had a low correlation with the formulated definition. For a high correlation between the respondents' definition and the formulated definition, a ranking of 3 was allocated.

From the 42 responses, four respondents did not provide definitions. The 38 remaining responses are captured and rated in **Table 7-3**.

Table 7-3: Ranking the similarity between respondents' definition and the formulated definition of ecosystem services.

THE DEFINITIONS PROVIDED BY RESPONDENTS (N=38)	RATING
<i>The benefits that humans obtain from ecosystems. It is formed by the interaction between living and non-living organisms.</i>	2
<i>To be honest, I have never heard of ecosystem. If I have to guess, it has something to do with protecting the environment and ecosystems.</i>	1
<i>The cycling of used products in a green environmentally friendly system. These systems are developed to reduce the strain on physical infrastructure and not to harm the environment.</i>	1

THE DEFINITIONS PROVIDED BY RESPONDENTS (N=38)				RATING
<i>From a Township Establishment perspective: Provision of basic services such as water and sewer, supporting services complying to the restrictions set out by the project environmentalist and geologist, regulating the restrictions set out by the service departments at the Municipality (e.g., Storm water management) and provision of supportive facilities such as schools, shops etc.</i>				1
<i>The regulation of climate along with the production of oxygen, food, and water through natural vegetation to create a functional natural environment.</i>				2
<i>The benefits/resources provided to humans/cities and include Provision, Cultural, Supporting and Regulating services.</i>				3
<i>Recognition and integration of ecosystems into the urban environment.</i>				2
<i>The natural and interactive functioning of the natural environment (and urban environment in some cases) through which that environment is regulated, provided for, and supported - inclusive of a cultural aspect for humans.</i>				2
<i>The service or benefits that an ecosystem can provide society.</i>				3
<i>Assume it is the process or services delivered by Environmental Practitioners to ensure the protection of the ecosystem in anyway.</i>				1
<i>Services related to ecosystems i.e., services associated to identify, determine, value ecosystems.</i>				2
<i>Environmental Impact Assessments and Basic Assessments</i>				1
RATING CRITERIA	1→Low correlation	2→Moderated correlation	3→High correlation	
<i>Town Planning which takes natural resources and systems into account.</i>				1
<i>Things humans obtain from the ecosystem, functions such as clean air, food, water filtration, flood prevention, noise reduction, recreation, climate regulation, and nature education.</i>				3
<i>Something to do with the natural aspects in a city.</i>				2
<i>It is the services and benefits that ecosystems offers to mankind.</i>				3
<i>A variety of natural processes balancing natural ecosystems to the benefit of a sustainable environment.</i>				2
<i>Nature sensitive urban development.</i>				1
<i>The benefits people obtain from ecosystem.</i>				3
<i>Policy framework aimed at protecting the ecosystem.</i>				1
<i>Benefits for people via regulation, enhancement of cultural values, provision of necessities, and production of consumables that are more compatible with the ecosystem than the present services.</i>				3
<i>Ecosystems are communities formed by the interaction between living (plants, animals, microbes) and non-living organisms (air, water, mineral soil). Human beings are both part of ecosystems and benefit from ecosystems in many ways. The benefits are known as ecosystem services.</i>				2
<i>Provision of clean water and air, healthy soil, bio-diverse fauna, and flora, so that we can drink clean water, breathe pure air, and grow healthy food. Ecosystem services do not create waste; its function is circular.</i>				2
<i>The public benefit which accrues from the natural environment</i>				3
<i>How the Ecosystem can serve to the benefit of the built environment.</i>				2
<i>The many and varied benefits to humans gifted by the natural environment and from healthy ecosystems</i>				3
<i>It relates to ecosystems (e.g., Agri, forest, grassland, etc.) that provides clean air, socio-physiological impacts, mitigate weather impacts, etc.</i>				2

THE DEFINITIONS PROVIDED BY RESPONDENTS (N=38)			RATING
<i>It is the way natural systems directly or indirectly benefit humans or enhance social welfare, i.e., living conditions / habitation. production of food, services etc.</i>			3
<i>Services provided by nature on which human beings are reliant on for survival.</i>			3
<i>Providing planning in a sustainable manner, working with the environment as an advantage, rather than a disadvantage. In order to provide a holistic approach to planning, in all forms.</i>			1
<i>Services" that are derived from ecosystems, such as agriculture/food production, climate control, leisure, etc.</i>			2
<i>This is basically the benefits that people gain from ecosystems support human well-being.</i>			3
<i>The alignment of the ecosystem with planning decisions and the effect of planning decisions on the environment.</i>			1
<i>It is services that are available in nature that can be used to service communities.</i>			3
<i>The way in which humans' benefits from the environment and the enhancing of social welfare.</i>			2
<i>Services provided by nature by way of filtering water, reducing storm water runoff etc.</i>			2
<i>Include everything working together as one system.</i>			1
<i>Natural accruing cycle.</i>			1
RATING CRITERIA	1→Low correlation	2→Moderated correlation	3→High correlation

Source: Own construction based on questionnaire results (2020).

Figure 7-8 visually represents the level of similarity ascribed to the definitions provided by the respondents with the formulated definition for ESs.

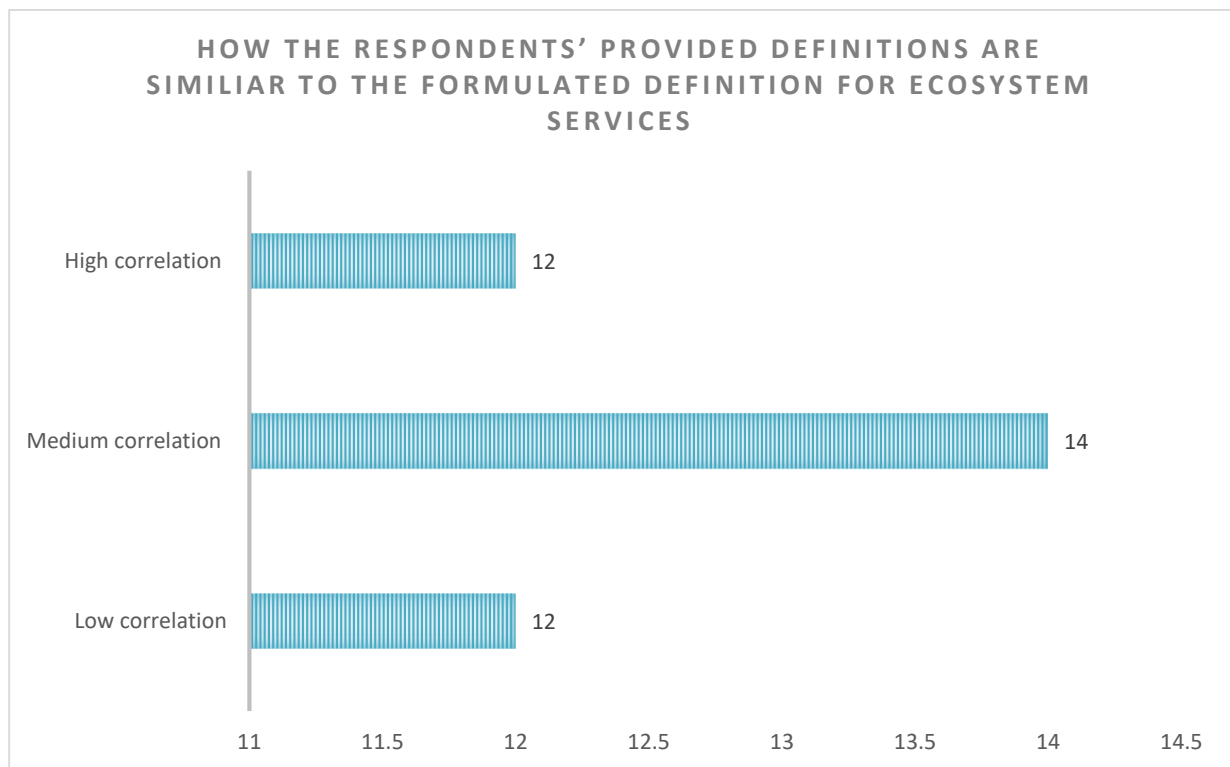


Figure 7-8: Level of similarity between respondents' definitions and the formulated definition of ecosystem services.

Considering **Figure 7-8**, twelve (n=12) respondents provided definitions with low level similarity, while 12 other respondents provided definitions ranked as presenting a high level of similarity. While most of the planners ranked their familiarity of the ESs concept in **Figure 7-7** as somewhat familiar, the same could be seen from the responses in **Figure 7-8**, whereas the majority of the respondents' only had a moderate similarity (n=14) with the formulated definition. These findings confirm that there is, however, generally a moderate-to-low knowledge and comprehension of the ESs concept amongst the majority of the South African urban planners included in the sample.

7.4.2.3 Examples of ecosystem services provided by the respondents.

Question 7 requested respondents to provide some examples of ESs. Forty (n=40) open-ended responses were gathered and analysed thematically according to four themes, namely the four ESs categories of provisioning, regulating, cultural and habitat and supporting services, discussed in the literature investigation (c.f. 4.4).

The four themes and their related data were presented in a “word cloud”. Word clouds are visual representations of text (DeNoyelles & Reyes-Foster, 2015:4). The text is display in different sizes and colours and are based on frequencies. The larger sized and bolded words represent the most frequently words found within the text, in this case examples presented by respondents.

7.4.2.3.1 The provisioning ecosystem services category.

Figure 7-9 illustrates the word cloud for the **provisioning ESs category**. A total of twenty (n=20) provisioning ESs examples were provided by the respondents. Seven (n=7) of the respondents explicitly mentioned the “production’ or “provision” of sources. As seen in **Figure 7-9**, the provisioning ESs most recognised by the respondents were food (n=5) and water (n=5).



Figure 7-9: Examples provided by respondents related to the provisioning ecosystem services category.

Source: Own construction based on questionnaire results (2020).

Other provisioning ESs examples provided by the respondents, which were also recognised in the literature investigation, included the provisioning of medicinal resources, as well as materials such as wood and fuel.

7.4.2.3.2 The regulating ecosystem services category

The second ESs category, the **regulating ESs**, and accompanied examples are illustrated in the word cloud, **Figure 7-10**.

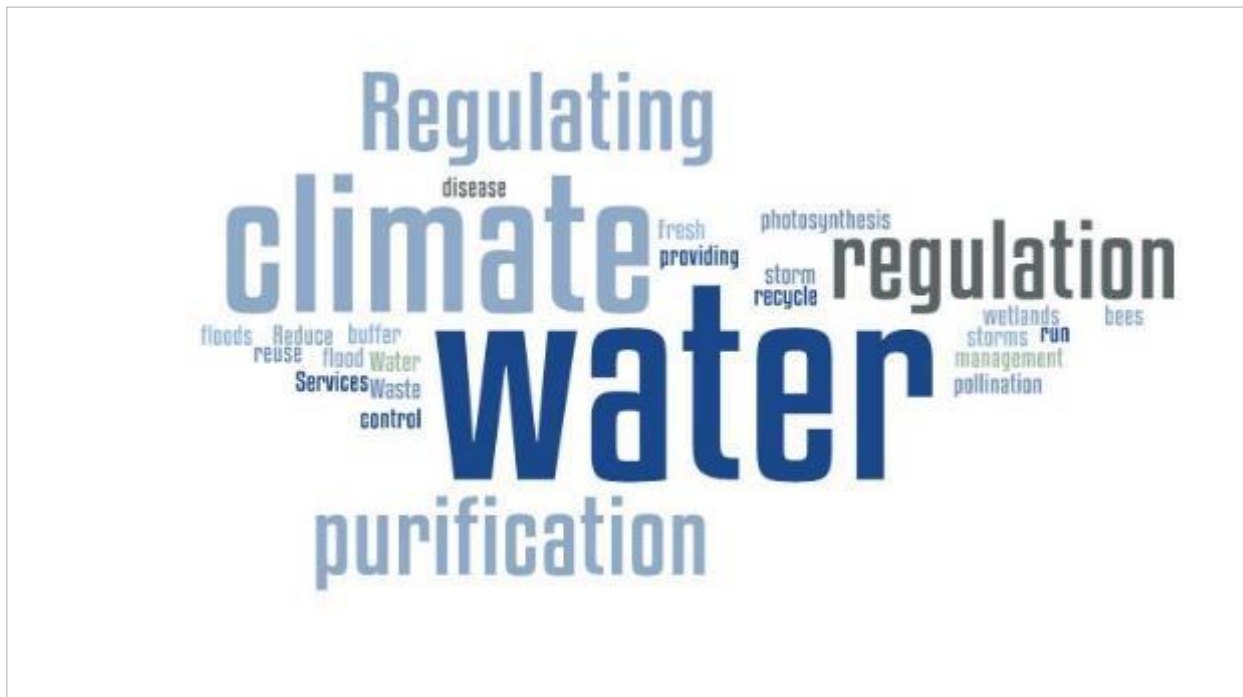


Figure 7-10: Examples provided by respondents related to the regulating ecosystem services category.

Source: Own construction based on questionnaire results (2020).

A total of twenty-nine ($n=29$) regulating ESs examples were provided by the respondents. The main examples provided were climate regulation ($n=6$), water regulation or purification ($n=8$), storm water or flood management ($n=4$) (**Figure 7-10**). As also recognised in the literature investigation (c.f. 4.6.1) the regulating ESs are more familiar to urban planners as they deal with typical urban issues, for instance storm water management (*Di Marino et al.*, 2019:645).

Other examples related to regulating ESs included waste and diseases control, the regulation of pollution and clean air, the pollination process, nutrient cycle and soil formations, the photosynthesis process, and the production of atmospheric oxygen.

7.4.2.3.3 The cultural ecosystem services category

Only a few of the respondents were familiar with **cultural ESs** (n=5). The cultural ESs mentioned by the respondents are illustrated in **Figure 7-11**.

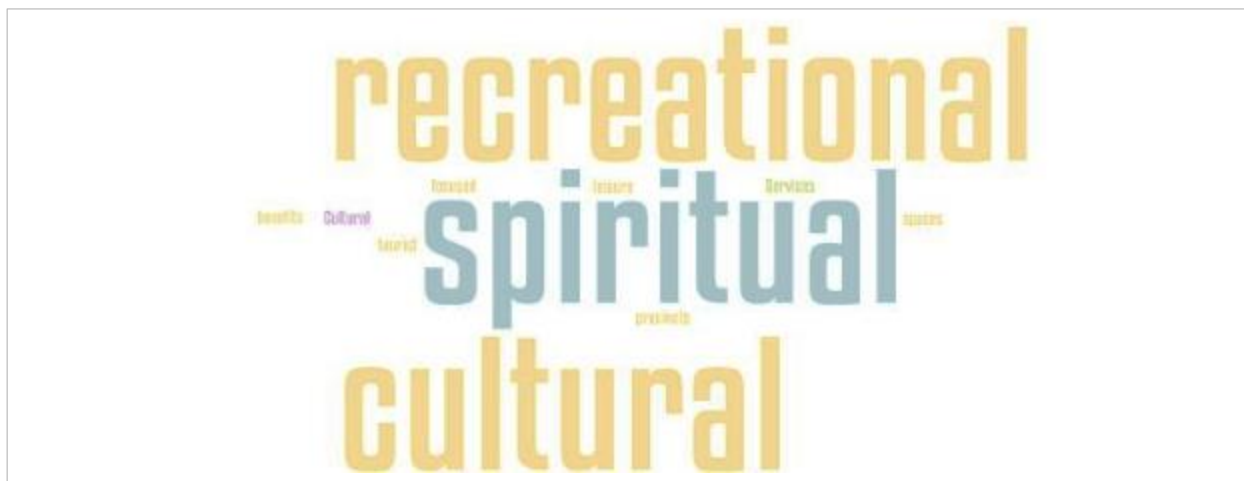


Figure 7-11: Examples provided by respondents related to the cultural ecosystem services category.

Source: Own construction based on questionnaire results (2020).

Leisure and recreational benefit (n=3) examples were provided, as well as spiritual and cultural serviced (n=2). One respondent (n=1) mentioned tourism. However, none of the respondents mentioned aesthetic cultural services.

7.4.2.3.4 The habitat and supporting ecosystem services category.

Only 8% (3 out of 40) of the respondents mentioned examples of ESs related to the **habitat and supporting ESs category**. The examples mentioned are illustrated in **Figure 7-12** and included “maintaining conditions for life” and the provision of “habitats” and “biodiversity”.



Figure 7-12: Examples provided by respondents related to the habitat and supporting ecosystem services category.

Source: Own construction based on questionnaire results (2020).

7.4.2.3.5 Quantifying the findings

Figure 7-13 illustrates the total quantity of respondents according to each theme (the four ESs categories) that provided examples. The purpose of **Figure 7-13** is drafted to determine which ESs category is more familiar to South African urban planners.

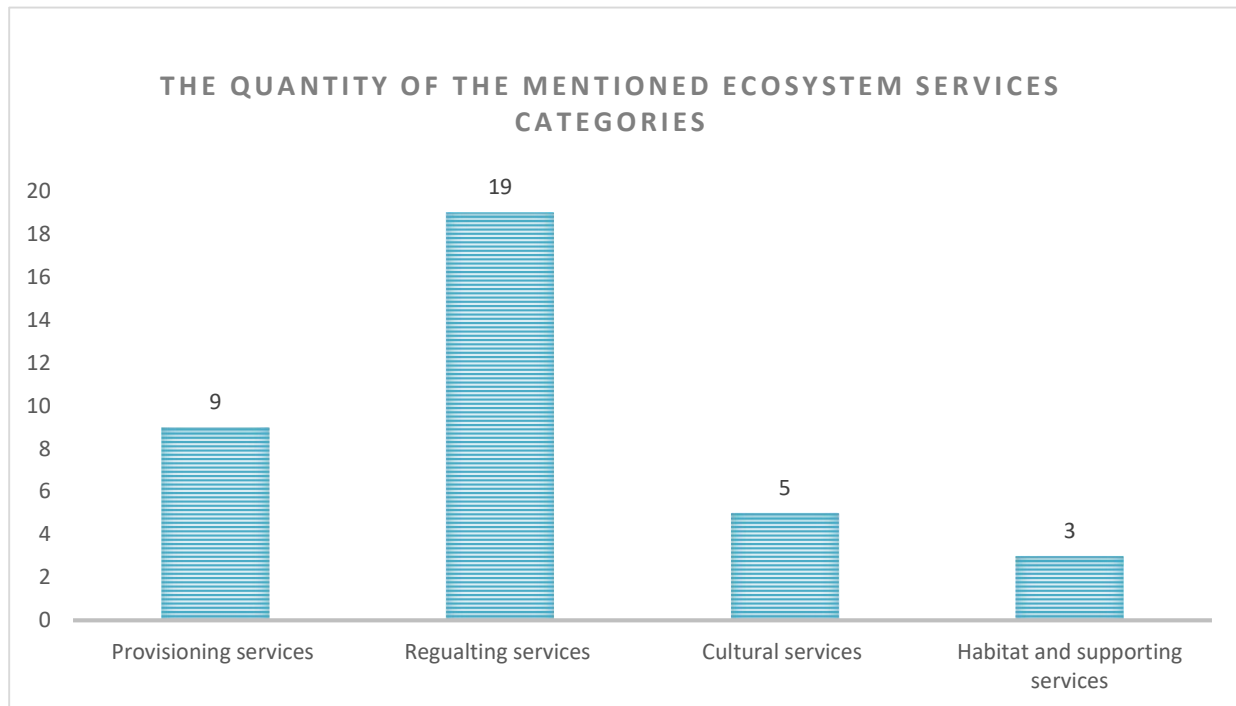


Figure 7-13: Whichever ecosystem services category is more familiar to South African urban planners.

When considering **Figure 7-13**, it could be concluded that from the sample of South African urban planners, all four categories of ESs were recognised. Some ESs categories were however more familiar than others. The majority of examples provided by the respondents fell into the regulating ESs category ($n=19$). These finding reflect reports in the literature by Di Marino *et al.* (2019:645) claiming that regulating ESs are often more familiar to urban planners as they deal with typical urban issues. Although the literature furthermore indicated that the cultural ESs category may be well-known among urban planners and that they are the most frequently emphasised in urban planning practice (Anderson *et al.*, 2016:446, Chen, 2017:190) the results of Question 7 were contradictory. **Figure 7-13** presents that only 13% (5 of the 40) respondents mentioned examples of ESs related to the cultural ESs category. Within the "Habitat and supporting ESs category" only three ($n=3$) respondents mentioned examples, indicating that not all South African urban planners are yet familiarised with this category of ESs.

Moreover, 43% ($n=17$) of the respondents mentioned the examples of ESs as the *green spaces* that provide ESs. Examples provided by the respondents included 'Bioswales, "wetlands", "open spaces", "trees", "natural water", "green spaces" and "water courses", "water ecosystem" "permeability of soils", "natural open spaces (veldt)", "natural bush", "urban-ecosystems", "forest

ecosystems,” “aqua-ecosystems”, “game reserves”, “urban farming on rooftops”, “bio-sensitive areas”, and “agricultural estate”. This could indicate that some South African urban planners are familiar with the linkage between planning for these green spaces to generate ESs, however, are not yet familiar with the broad spectrum of ESs categories and accompanied ESs. This evidence is in line with the studies of Sitas *et al.* (2014) and Du Toit *et al.* (2018:256) finding that African urban planners tend to struggle with poor awareness and lack of knowledge regarding comprehensive ESs generated by different green spaces.

7.4.2.4 Respondents’ rankings of importance regarding planning for ecosystem services

Figure 7-14 clearly indicates that the majority of respondents’ (88%) ranked planning for ESs as either as “very important” (n=19) or close to “very important” (n=18)

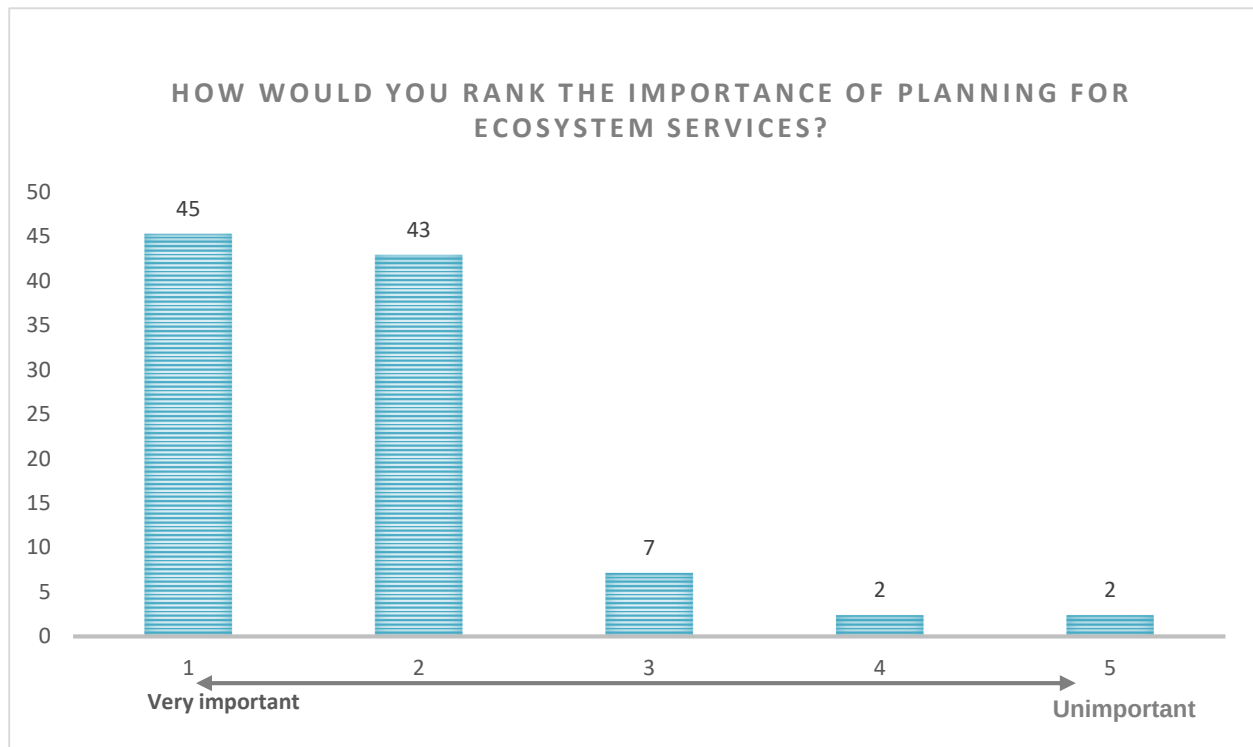


Figure 7-14: The importance of planning for ecosystem services.

For further analysis of Question 8, a cross-tabulation was completed (**Table 7-4**) between Question 8 and Question 2 (Question 2: Which SACPLAN registration applies to you). The purpose of the cross-tabulation was to determine if different SACPLAN registered Planners ranked the importance of planning for ESs differently. As seen in **Table 7-4**, the cross-tabulation calculated an $V \sim 0.127$. This indicated a small correlation or practical non-significance between the planners SACPLAN registration and the importance of planning for ESs.

Table 7-4: The cross-tabulation between Planners' professional registration and ranking the importance for the planning of ecosystem services.

Q2 WITH Q8		QUESTION 8: How would you rank the importance of planning for ecosystem services?			
Question 2: WHICH SACPLAN registration applies to you?	OPTIONS	1-2 VERY IMPORTANT	3	4-5 UNIMPORTANT	TOTAL
	Candidate planner	3 (50.0%)	1 (16.7%)	2 (33.3%)	6 (100%)
	Professional planner	15 (41.7%)	12 (33.3%)	9 (25.0%)	36 (100%)
	TOTAL	18 (42.9%)	13 (31.0%)	11 (26.2%)	42 (100%)
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance	
0. .681		0.127		0.711	

The small correlation or non-practical significance in **Table 7-4** indicates there is no real difference between the opinion of a Candidate planner or Professional Planner when it comes to the importance of planning for ESs. It was already clear in **Figure 7-14** that most planners – regardless of their registration, agreed that ESs are important to plan for.

7.4.2.5 The level of consideration of ecosystem services in planning activities

Although the results from the previous question (section 7.4.2.4) clearly indicated that South African urban planners consider ESs as important considerations to plan for, **Figure 7-15** on the other hand evidently shows that only 17% of the respondents indicated that they “always” consider ESs in their planning activities. The majority of respondents specified they only “sometimes” consider ESs in their planning activities.

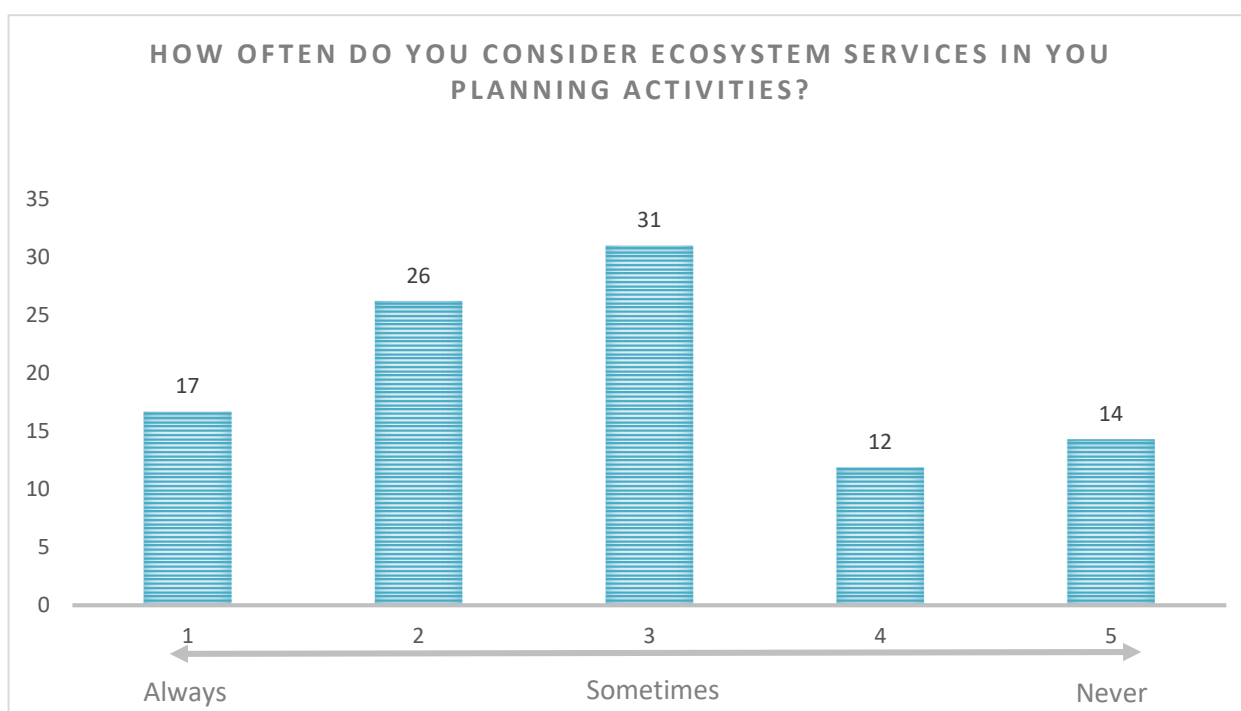


Figure 7-15: Respondents' frequency consideration of ecosystem services in planning activities.

A cross-tabulation between Question 9 (*How often do you consider ecosystem services in you planning activities*) and Question 8 (*How would you rank the importance of planning for ecosystem services*) are illustrated in **Table 7-5**. The purpose of the cross-tabulation was to determine a correlation between respondents' indication regarding the importance of ESs and how often they consider ESs in their planning activities.

Table 7-5: The cross-tabulation between the importance of ecosystem services and consideration of ecosystem services in planning activities.

Q8 WITH Q9		QUESTION 8: How would you rank the importance of planning for ecosystem services?			
QUESTION 9: How often do you consider ecosystem services in you planning activities?	OPTIONS	1 VERY IMPORTANT	2	3-5 UNIMPORTANT	TOTAL
	1-2 ALWAYS	13 (72.2%)	3 (16.7%)	2 (11.1%)	18
	3	3 (23.1%)	10 (76.9%)	0 (0.0%)	13 (100%)
	4-5 NEVER	3 (27.3%)	5 (45.5%)	3 (27.3%)	11 (100%)
	TOTAL	19 (45.2%)	18 (42.9%)	5 (11.9%)	42 (100%)
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance	
15.251		0.426		0.004	

In **Table 7-5** a clear medium effect or practical visible significance ($V \sim 0.426$) were found between planners' indication of the importance of ecosystem services and how often they consider

ecosystem services in their planning activities. Accordingly, it was evident when planners considered ESs as important (Question 8), they also indicated that they considered it in their planning activities (Question 9). The literature also indicated similar findings, presenting that the preservation and enhancement of green spaces and their associated ESs ultimately depend on the importance they are appointed in urban planning practice (Langenmeyer *et al.*, 2016:45). Overall, this result calls for the awareness making of the importance of the ESs concept among planners.

Moreover, question 9 was also cross tabulated with Question 4 (*Please indicate your years of experience*), for further analysis regarding planners' consideration of ecosystem services in their planning activities. **Table 7-6** illustrates the Cramer V-test value as 0.271, indicating a medium effect or practical visible significance of the connection between the years of experience of the planners and ranking of importance of planning for ESs.

Table 7-6: The cross-tabulation between the Planners' years of experience and ranking of importance of planning for ecosystem services.

Q4 WITH Q9		QUESTION 8: How would you rank the importance of planning for ecosystem services?			
QUESTION 4: Please indicate your years of experience	OPTIONS	1-2 VERY IMPORTANT	3	4-5 UNIMPORTANT	TOTAL
	4 years or less	6 (50.0%)	1 (8.3%)	5 (41.7%)	12 (100%)
	5-19	4 (28.6%)	7 (50.0%)	3 (21.4%)	14 (100%)
	More than 20	8 (50.0%)	5 (31.3%)	3 (18.8%)	16 (100%)
	TOTAL	18 (42.9%)	13 (31.0%)	11 (26.2%)	42 (100%)
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance	
6.182		0.271		0.186	

Ultimately, the results of **Table 7-6** illustrate that no matter the years of experience of the planners, almost half of the sample of planners (42.9%) still considered planning for ESs as very important. It was, however, alarming to see that 41.7% of the planners with 4 years or less experience was the group to consider planning for ESs as "unimportant".

7.4.2.6 Consideration of other aspects and concepts regarding an ecological approach among the respondents

To further explore the ecological aspects and concepts, question 10 focused on determining if the concepts of urban ecology and GI planning are taken into consideration within the planning activities of the respondents. The following definitions for the concepts were provided in the

questionnaire and respondents had the opportunity to indicate if they consider the concepts or not.

Green Infrastructure planning: a planning approach that aims to develop networks of green and blue spaces in urban areas, designed and managed to deliver a wide range of ecosystem services and other benefits.

Urban ecology: to study and include knowledge in urban planning practice on how human and ecological processes could coexist in human-dominated environments.

In **Figure 7-16** a total of 71% of the respondents specified “yes” they have previously considered GI planning in their planning activities. Almost the same trend was found with the concept of urban ecology, where 67% of the respondents indicated “yes”.

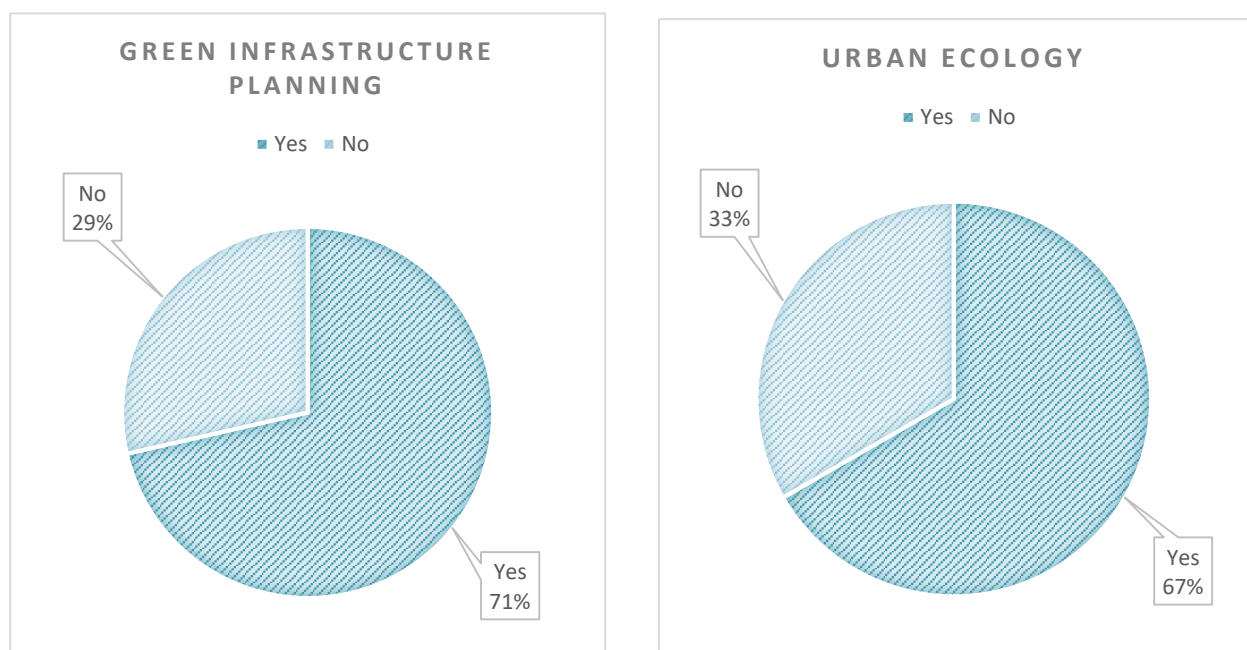


Figure 7-16: Respondents' consideration of green infrastructure planning and urban ecology in urban planning activities.

In order to determine if planners in different sectors of occupation (public and private sectors) frequently consider ecological aspects and concepts in urban planning practice differently, a cross-tabulation was completed between Question 1 (*Please indicate your sector of employment*) and Question 10 (*Which of the following concepts have you previously taken into consideration in your planning activities?*). **Table 7-7** illustrates the frequency of planners' sector of occupation and the consideration of the GI planning concept. A small effect or practical non-significance was present since $V=0.073$. Therefore, the findings of this cross-tabulation illustrated an extremely

low correlation between of the sector of occupation of the planners and consideration of the GI planning concept.

Table 7-7: A cross-tabulation between the frequency of the sector of occupation of the planners and consideration of the green infrastructure planning concept.

Q1 WITH Q10		QUESTION 10: Which of the following concepts have you previously took into consideration in your planning activities? (GREEN INFRASTRUCTURE PLANNING)		
QUESTION 1: Please indicate your sector of employment	OPTIONS	NO	YES	TOTAL
	Private sector	10 (30.3%)	23 (69.7%)	33 (100%)
	Public sector	2 (22.2%)	7 (77.8%)	9 (100%)
	TOTAL	12 (28.6%)	30 (71.4%)	42 (100%)
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance
0.226		0.073		0.634

The cross-tabulation illustrated in **Table 7-7** indicated that 77.8% of the planners in the Public sector often considered the GI planning concept while 69.7% of those planners in the Public sector considered the GI planning concept.

Table 7-8, considers the “urban ecology” concept and illustrates the frequency of the sector of occupation of the planners and consideration of the concept in their planning activities.

Table 7-8: A cross-tabulation between the frequency of the sector of occupation of the planners and consideration of the urban ecology concept.

Q1 WITH Q10		QUESTION 10: Which of the following concepts have you previously taken into consideration in your planning activities? (URBAN ECOLOGY)		
QUESTION 1: Please indicate your sector of employment	OPTIONS	NO	YES	TOTAL
	Private sector	20	13	33
	Public sector	8	1	9
	TOTAL	28	14	42
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance
2.545454545		0.246182982		0.110612074

The cross-tabulation detected a $V \sim 0.246$, illustrated in **Table 7-8**, and therefore reported a medium effect or practical visible significance between the two variables. It could further be seen in **Table 7-8**, that 89% of the planners in the Public sector indicated “yes”, while only 60% of the planners in the Private sector indicated “yes”. In contrast with the GI planning” concept (Table 7-7), it is clear that the Public sector considers the urban ecology concept more often in their planning activities, than the Private sector.

Hereafter follows the reasons provided by respondents for why they have previously considered these ecological aspects and concepts in urban planning activities.

7.4.2.7 Respondents' reason for considering the ecological considerations in urban planning activities.

Question 11 was asked to gauge the motives behind the consideration of the ecological aspects and concepts such as ESs, urban ecology and GI planning. The respondents could have chosen between any of the following motivations: own knowledge, client or tender stipulation, a problem that required a creative solution, result of public participation, and the recommendation of a specialist. The results follow in **Figure 7-17**.

39% of the respondents' identified "own knowledge" as the main reason for considering the concepts in urban planning activities.

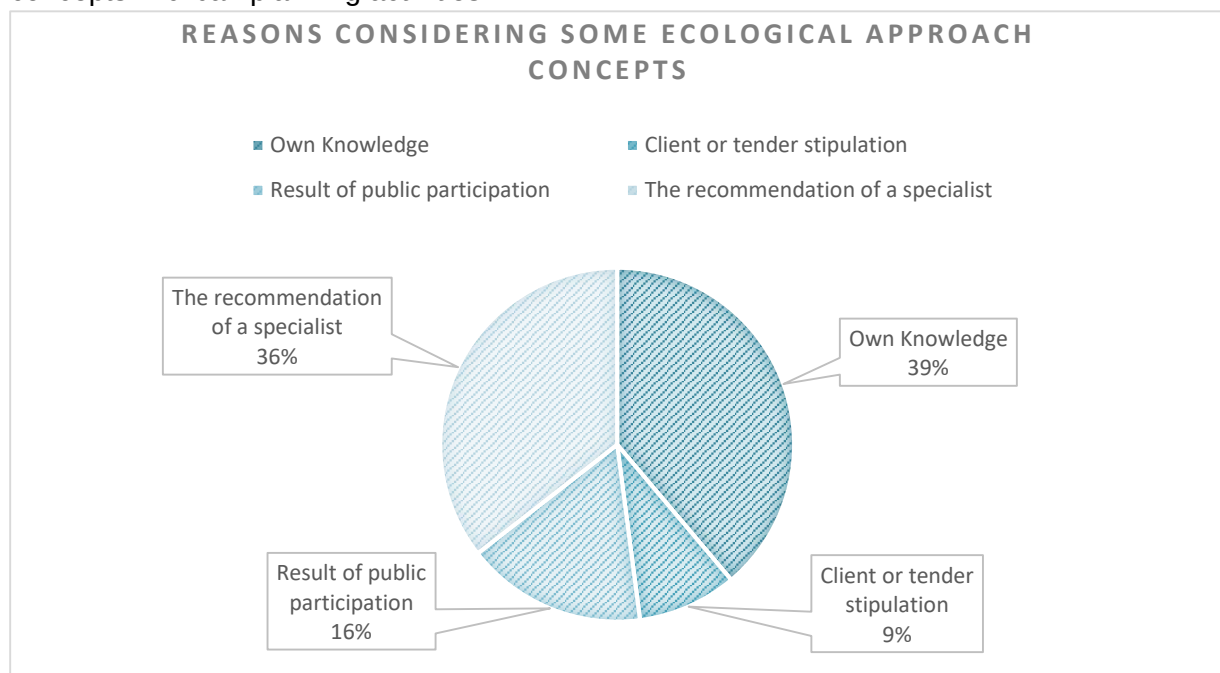


Figure 7-17: Respondents' reasons for considering aspects and concepts related to ecological approaches.

Moreover, 36% agreed on "the recommendation of a specialist" and 16% on "results of public participation". Only 9% indicated "client or tender stipulation" as motive for considering these concepts in urban planning activities.

Respondents furthermore had the opportunity to provide "other" or their own reasons for considering the concepts in urban planning activities. Eleven (n=11) additional reasons were provided by the respondents, as included in **Table 7-9**.

Table 7-9: Additional reasons provided by respondents regarding the incorporation of some ecological approach aspects and concepts.

RESPONDENTS' ADDITIONAL REASONS
<i>Most of the time the bulk service infrastructures are not capable to handle additional developments, resulting to the development of alternative solutions.</i>
<i>Basic regulations as stipulated by the Municipality</i>
<i>Comment received from internal Environmental Management Section.</i>
<i>Council's Environmental Department requirements</i>
<i>Usually, these concepts are included in a report / Environmental Impact Assessment if and when the Council requires such report for a town planning application.</i>
<i>Conservation</i>
<i>Statutory/policy reasons to comply with environmental legislation</i>
<i>Has to be done if any NEMA regulations are triggered, this is mostly done by an environmental consultant or environmental planner.</i>
<i>Buffer areas and detail alignment of services away from sensitive areas</i>
<i>Increase food security</i>
<i>Development in green spaces do not mean no development, it means developing sustainably.</i>

Source: Own construction based on questionnaire results (2020).

7.4.2.8 Challenges specified by the respondents encountered the application or implementation of aspects and concepts related to ecological approaches in planning practice.

Discovered through the literature investigation was that it is important to gain knowledge and the views of planning practitioners to uncover the barriers or challenges preventing urban planners from incorporating ecological approaches (Mascarenhas *et al.*, 2014:1287; La Rosa, 2019:1. Question 12 was asked to determine some of the challenges encountered in the consideration and integration of ecological aspects and concepts in South African urban planning practice. The results are illustrated in **Figure 7-18**.

While the literature clearly emphasised ecological literacy (Pasquini & Enqvist, 2019:9), the improvement of education among decision-makers (Du Toit *et al.*, 2018:256; Huston, 2018:135), and a “knowledge foundation” (Niemelä *et al.*, 2010; Schäffler *et al.* 2013:180; Mascarenhas, 2017:14; Du Toit *et al.* 2018:256) providing examples of ESs and what the benefits of ESs have for urban areas (Mascarenhas *et al.*, 2014: 290), the results of question 12 differed. From the responses only 43% indicated “lack of knowledge regarding the concepts” and “the lack of case-studies regarding the benefits thereof” (26%) as challenges. It was discovered that the majority of respondents considered financial limitations as a challenge (67%). The challenge was also identified in literature, that in South Africa ecological considerations often fail to compete against

finances for the many other socio-economic needs (e.g., roads, clinics, housing shortages) (Cilliers, 2019a:350).

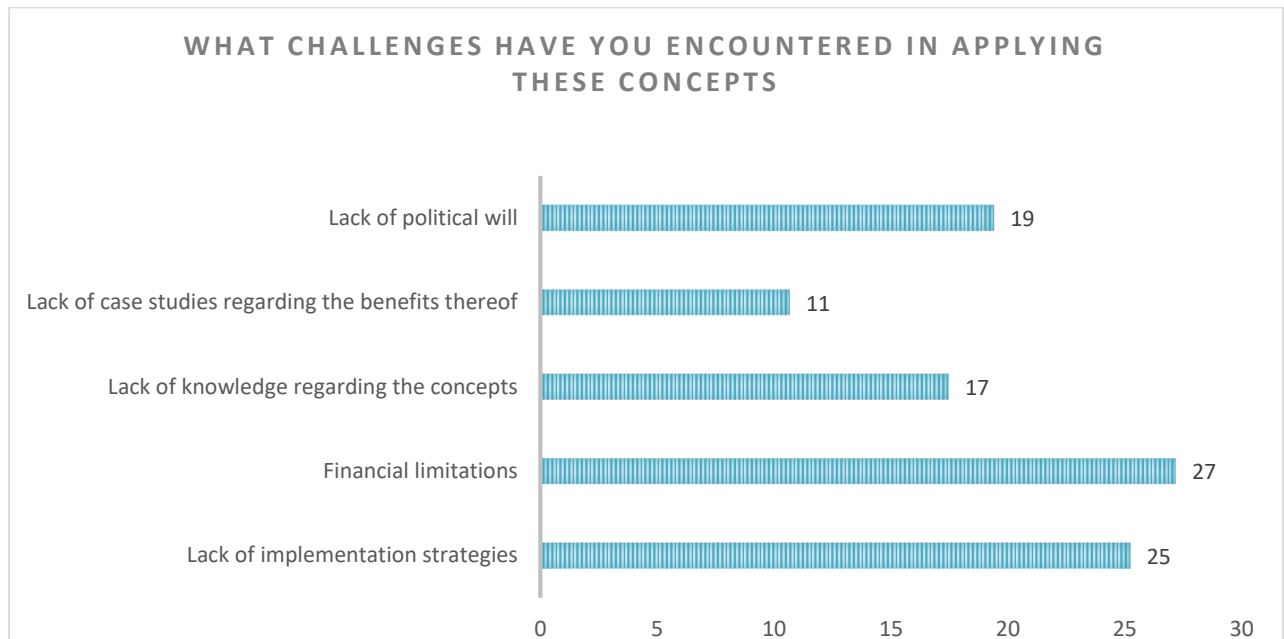


Figure 7-18: Challenges indicated by the respondents encountered in the application or implementation of ecological approach concepts in urban planning practice.

Furthermore, **Figure 7-18** illustrates that “Lack of implementation strategies” with 62% responses was the second main challenge indicated. In the study of Cilliers (2019a:455) a similar challenge was identified, claiming that South Africa urban planning practice is influenced by the lack of “know-how to” knowledge or in other words, a lack of implementation strategies on how to implement ecological considerations in planning practice.

Similar to the previous question (Question 11), respondents furthermore had the opportunity to provide “other” or their own option regarding challenges encountering application or implementation. Four (n=4) additional challenges were identified by the respondents and are included in **Table 7-10**.

Table 7-10: Additional challenges identified by respondents encountering the application or implementation of ecological considerations.

ADDITIONAL SPECIFIED CHALLENGES
<i>Clients choose the fastest outcome, although planners can recommend, the decision lies with the client.</i>
<i>Long-term costs for the maintenance of ecosystems to municipalities.</i>
<i>The developer does not want to incur additional costs when not required.</i>
<i>Inability of regulating authorities to manage.</i>

Source: Own construction based on questionnaire results (2020).

In order to determine if public and private sector planners indicated different challenges a cross-tabulation between Question 1 and above-discussed Question 12, was captured in **Table 7-11**. From the cross-tabulations a $V \sim 0.132$ was detected, indicating a small effect or practical non-significance between Question 1 and 12.

Table 7-11: The cross-tabulation between the sector of occupation of the planners and the challenges they have identified encountering the application or implementation of ecological consideration.

Q1 WITH Q12	QUESTION 12: What challenges have you encountered in applying ecological concepts in planning practice?						
QUESTION 1: Please indicate your sector of employment	OPTIONS	Financial limitations	Lack of political will	Lack of case studies regarding the benefits thereof	Lack of knowledge regarding the concepts	Lack of implementation strategies	TOTAL
	Private sector	21 (63.6%)	13 (39.4%)	8 (24.2%)	15 (45.5%)	20 (60.6%)	77 (100%)
	Public sector	7 (77.8%)	7 (77.8%)	3 (33.3%)	3 (33.3%)	6 (66.7%)	26 (100%)
	TOTAL	28 (27.18%)	20 (19.4%)	11 (10.7%)	18 (17.5%)	26 (25.2%)	103 (100%)
Pearson Chi-Square		Cramer's V-test			Cramer's V approximate significance		
1.800087675		0.132199014			0.772466313		

The findings of the cross-tabulation (**Table 7-11**) illustrate that the most significant challenge identified by private sector planners were financial limitations (64%), while the most significant challenge identified by the public sectors planners were the lack of political will (78%), while only 40% of those planners in the private sector indicated lack of political will as a challenge encountering the application or implementation of ecological considerations in urban planning activities.

7.4.2.9 *The multi-functionality concept in South African urban planning practice*

Three different definitions related to the concept of multi-functionality in urban planning practice were provided in Question 13. The three different concepts of multi-functionality were identified following the literature investigation as, 1) multi-functionality as urban land-use concept, 2) the concept of multi-functionality in an urban landscape, and 3) multi-functionality as the GI planning principle. Question 13 intended to determine which multi-functionality concept is more familiar to South African urban planning practitioners. As such, the three different definitions of multi-functionality included in Question 13 were as follows:

- The spatial arrangement and concentration of mono-functional urban landscape elements (e.g. agricultural, conservation, and recreational land-uses) within an individual urban landscape (***multi-functionality as urban land-use concept***).
- To concentrate and combine several land-uses (e.g. residential, commercial and institutional) in order to have more than one activity or socio-economic function within the same urban space (***the concept of multi-functionality in an urban landscape***).
- The green infrastructure planning principle that entails the capacity of a space to provide multiple ecosystem services within the same space (***multi-functionality as the green infrastructure planning principle***).

Each respondent had the opportunity to choose one of these definitions, that according to them, personify the best definition for the concept “multi-functionality” of spaces. The results are illustrated in **Figure 7-19**.

In response to Question 13, most of those surveyed indicated in **Figure 7-19** the “Multi-functionality as urban land-use concept” as the chosen definition for the concept “multi-functionality” of spaces (71%). This substantiates previous findings in literature, recognising that planners are often more familiar with the multi-functionality as land-use concept (Rodenburg, 2004:274).

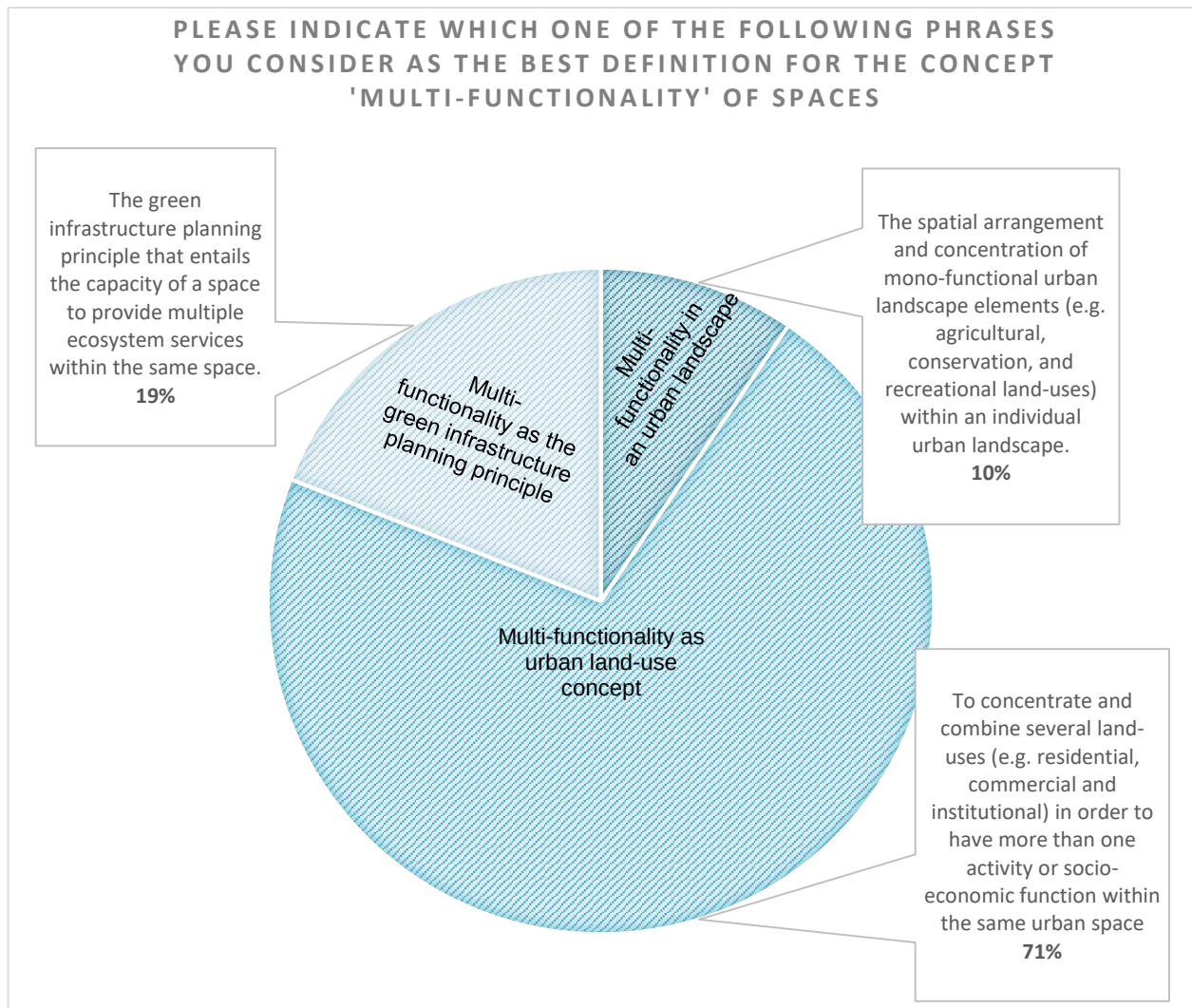


Figure 7-19: Respondents' chosen definition for the concept 'multi-functionality' of spaces.

As put forward by Hansen *et al.* (2017:43) and Di Marino *et al.* (2019:644) the concept that seems to be overlooked by urban planners is to plan for multi-functionality based on the GI planning principle. As might be expected, evidence from the questionnaire indicated that only 19% of the South African urban planner respondents recognised the “multi-functionality as the green infrastructure planning principle” concept as an agreeable definition for the “multi-functionality” of a space. To further investigate this finding, Question 13 was cross-tabulated in **Table 7-12** with Question 10 (*Have you previously taken GREEN INFRASTRUCTURE PLANNING into consideration in your planning activities*). The purpose of the cross-tabulation was to determine if planners indicated “yes” in Question 10, also indicated the “Multi-functionality as the green infrastructure planning principle” as the agreeable definition for multi-functionality.

Table 7-12: The cross-tabulation between Question 10 (Green Infrastructure Planning concept) and Question 13 (the concept of multi-functionality as the green infrastructure planning principle).

Q10 GI WITH Q13	QUESTION 13: Please indicate which ONE of the following phrases do you consider as the best definition for the concept 'MULTI-FUNCTIONALITY' of spaces				
QUESTION 10: Have you previously took green infrastructure planning into consideration in your planning activities	OPTIONS	Multi-functionality as the green infrastructure planning principle	Multi-functionality in an urban landscape	Multi-functionality as urban land-use concept	TOTAL
	YES	8 (26.7%)	2 (6.7%)	20 (66.7%)	30 (100%)
	NO	0 (0%)	2 (16.7%)	10 (83.3%)	12 (100%)
	TOTAL	8 (19.0%)	4 (9.5%)	30 (71.5%)	42 (100%)
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance	
4.433		0.3248		0.1089	

The cross-tabulation in **Table 7-12** detected a $V \sim 0.325$, indicating a medium effect or practical visible significance between the two variables. With this correlation it was found that the respondents that indicated “no” in Question 10 also did not indicate the “Multi-functionality as the green infrastructure planning principle” as the best definition in Question 13, while the 27% of respondents that selected “yes” in Question 10, also indicated the “Multi-functionality as the green infrastructure planning principle” as the best definition for multi-functionality. The results could indicate that planners need to be familiar with the GI planning and the incorporation thereof in order to recognise “Multi-functionality as the green infrastructure planning principle” as the agreeable definition for multi-functionality.

The following section reflects on the environmental worldview of the respondents and whether it could be related to the consideration of ecological aspects and concepts in South African urban planning practice.

7.4.3 The environmental worldview analysis of the sample of South African urban planners

This study is the first, to the knowledge of the researcher, to study environmental worldviews within the South African urban planning practice. The New Ecological Paradigm (NEP) scale is an extensive survey-based scale widely employed to measure respondents' environmental worldview based on a respondents' level of agreement on the 15-items. The scale has two main directions, an ecocentric worldview (pro-environmental) or an anthropogenic worldview (humans as independent from nature) (Wilhelm-Rechmann *et al.*, 2014:207, c.f. 7.3.2.3). Question 14 conducted the NEP-scale and included the 15-items. Respondents' had the opportunity to

indicate their level of agreement on the 15-items based on a Likert-scale of “agree”, “mildly agree”, “neutral”, “mildly disagree”, and “disagree”.

Table 7-13 indicates the respondents’ responses to the NEP-scale. The mean score for the eight Pro-NEP or “ecocentric” items (the uneven numbered questions indicated in the grey colour) responses were expected to be relative high scores (out of 5) or in other words high scoring in “agree” or “mildly agree” responses. Whereas the seven Pro-DSP or “anthropogenic view” items (the even numbered questions indicated in the white colour) were expected to have a relative low score (out of 5) or high scored “mildly agree” or “disagree” responses for an ecocentric worldview. As previously mentioned, the 15-items are further divided into five dimensions on which the 15-items are grounded. The five dimensions include, 1) Reality to limiting of growth, 2) Anti-anthropocentrism, 3) Vulnerability of nature's balance, 4) Anti-exceptionalism 5) Possibility of an eco-crisis. These dimensions are also included in **Table 7-13**, along with their accompanied NEP-scale items. Detail findings on the dimensions in **Table 7-13** could be found in **Annexure Two** of the dissertation.

Table 7-13: Responses of the sample of South African urban planners to the New Environmental Paradigm (NEP)-scale items.

THE NEP'S FIVE DIMENSIONS OF ENVIRONMENTAL THOUGHT	NEP SCALE ITEMS	CUMULATIVE PERCENTAGE					MEAN	S.D.
		AGREE	MILDLY AGREE	NEUTRAL	MILDLY DIS-AGREE	DIS-AGREE		
Reality to limiting of growth	1→ We are approaching the limit of the number of people the earth can support	42.9	23.8	14.3	9.5	9.5	3.8	1.3
	6 →The earth has plenty of natural resources if we just learn how to develop them	35.7	33.3	7.1	7.1	16.7	2.4	1.4
	11→ The earth is like a spaceship with very limited room and resources	28.6	33.3	31.0	4.8	2.4	3.8	1.0
Anti-anthropocentrism	2→Humans have the right to modify the natural environment to suit their needs	9.5	14.3	28.6	14.3	33.3	3.5	1.3
	7→Plants and animals have as much right as humans to exist	54.8	28.6	9.5	4.8	2.4	4.3	1.0
	12→Humans were meant to rule over the rest of nature	19.0	23.8	26.2	9.5	19.0	2.8	1.4
Vulnerability of nature's balance	3→When humans interfere with nature, it often produces disastrous consequences	47.6	33.3	9.5	4.8	4.8	4.1	1.1
	8→The balance of nature is strong enough to cope with the impacts of modern industrial nations	4.8	7.1	16.7	26.2	45.2	4.0	1.2
	13→The balance of nature is very delicate and easily upset	42.9	38.1	11.9	4.8	2.4	4.1	1.0
Anti-exceptionalism	4→Human ingenuity will ensure that we do NOT make the earth unliveable	7.1	35.7	31.0	14.3	11.9	2.9	1.1
	9→Despite our special abilities, humans are still subject to the laws of nature	54.8	42.9	2.4	0.0	0.0	4.5	0.5
	14→Humans will eventually learn enough about how nature works to be able to control it	7.1	14.3	33.3	23.8	21.4	3.4	1.2
Possibility of an eco-crisis	5→Humans are severely abusing the environment	54.8	31.0	4.8	7.1	2.4	4.3	1.0
	10→The so-called ecological crisis facing humankind has been greatly exaggerated	42.9	23.8	14.3	9.5	9.5	3.8	1.0
	15→If things continue on their present course, we will soon experience a major ecological catastrophe	42.9	23.8	14.3	9.5	9.5	3.8	0.9

Source: Own construction based on questionnaire results (2020).

Figure 7-20 illustrates the average responses on 15-items based the Five-Point-Linkert scale.

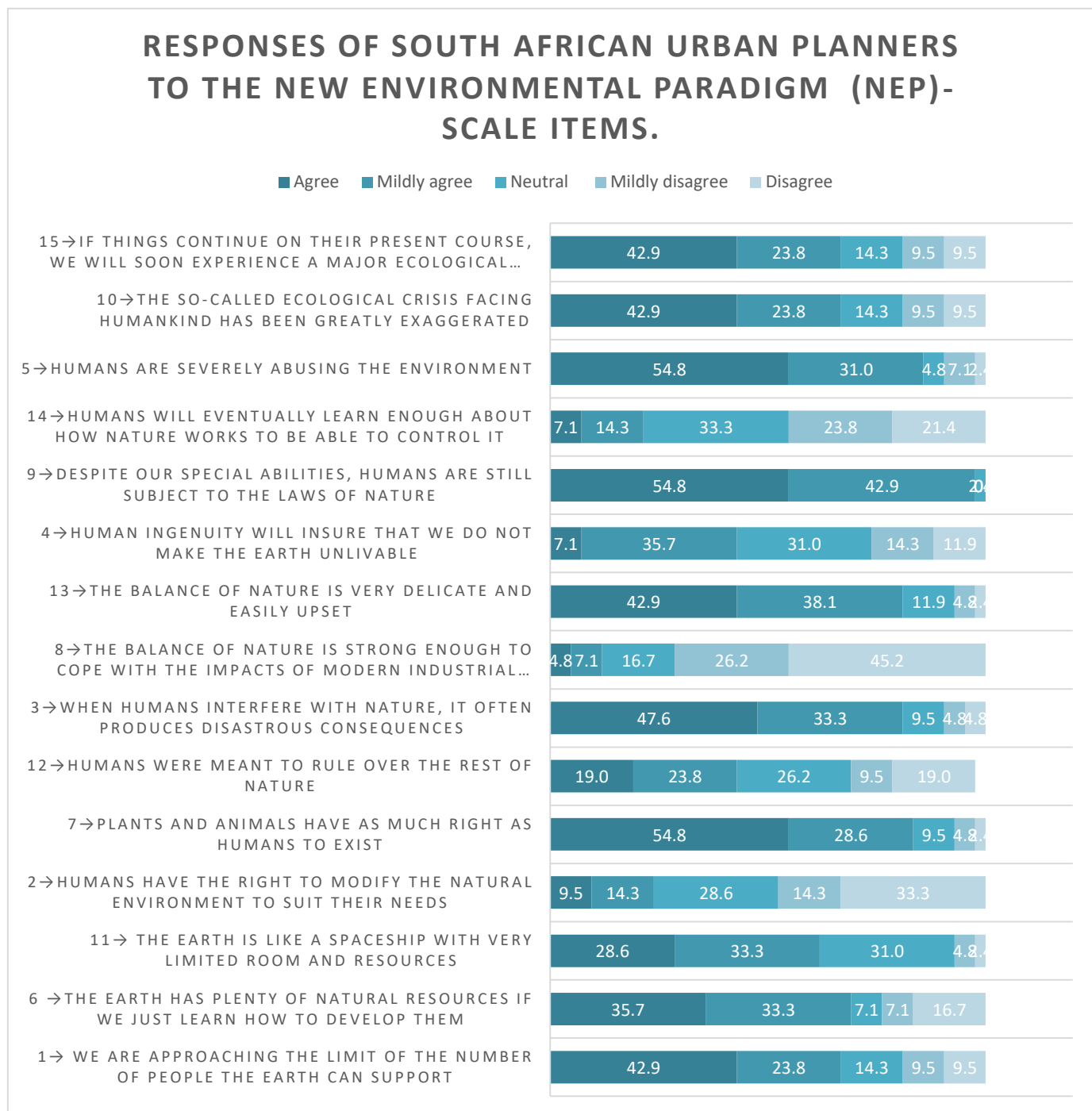


Figure 7-20: Average responses on 15-NEP items based the Five-Point-Linkert scale.

Source: Own construction based on questionnaire results (2020).

As seen in both **Table 7-13** and **Figure 7-20** the results of each of the 15-items were expressed as percentages and a mean average out of 5. The average score ranged between 2.9 and 4.5 out of 5. These results were also utilised to calculate average percentages for the five dimensions. A comprehensive discussion on the results of each of the five dimensions and their accompanied items are discussed and presented in **Annexure Two** of the dissertation. A discussion on the overall environmental worldview of the sample of South African urban planners follows.

7.4.3.1 The general environmental worldview of the sample of South African urban planners

The overall environmental worldview of the sample of South African urban planners was determined out of a score of 75 (15-items equals the five-point scale) which represents a maximum ecocentric environmental worldview. The lowest score was indicated as 39 out of 75, while the highest score was 73 out of 75. An average score of 56.1 out of 75 was determined. From these results the conclusion could be drawn that the sample of South African urban planners holds pro-NEP or ecocentric worldviews. This result, according to Colby & Mundial (1989:8) entails that humans (in this case the sample of South African urban planners) recognise that they have an ethical responsibility to the environment through co-development between nature and human activities.

7.4.3.2 Cross-tabulations with the environmental worldview of the sample of South African urban planners and the consideration of ecological aspects and concepts in planning practice

Cross-tabulations were completed between the sample of South African urban planners' environmental worldview (Question 14) and two other questions (Question 8 and Question 10) to determine if there is a relationship between South African urban planners' environmental worldview and their consideration of ecological aspects and concepts. The cross-tabulations and a discussion of the results follows.

A cross-tabulation between Question 14 and Question 8 (*How would you rank the importance of planning for ESs*) was completed to draw conclusions regarding South African urban planners' environmental worldview and how they ranked the importance of planning for ESs.

The cross-tabulation calculated a $V=0.325$, indicates a medium effect or practically visible, as seen in **Table 7-14**. These findings indicated that 88% of respondents that achieved 60 or more out of 75 (maximum ecocentric worldview) ranked the importance of ESs as very important. In other words, if the respondents achieved above 60 out of 75, the majority also indicated "very important" in Question 8. Thus, if respondents presented a high score out of 75 (in other words an ecocentric worldview) they also considered ESs as important to plan for. As a result, it is permissible to suggest that a planner's environmental worldview could have an influence on their perspective of how important it is to plan for ESs.

Table 7-14: The correlation between Planners' environmental worldview and how important they have ranked the importance of planning of ESs.

Q14 WITH Q8	QUESTION 8: How would you rank the importance of planning for ecosystem services?				
QUESTION 14: Please indicate your level of agreement on the following items	OPTIONS	1-2 VERY IMPORTANT	3	4-5 UNIMPORTANT	TOTAL
	1	0	0	0	0
	2	0	0	0	0
	3	14	2	0	16
	4	19	1	1	21
	5	4	0	1	5
	TOTAL	37	3	2	42
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance	
8.881634541		0.325167256		0.352379401	

Source: Own construction based on questionnaire results (2020).

A cross-tabulation between Question 14 and Question 10 (*Respondents' consideration to an ecological approach*) presented similar results to the cross-tabulation in **Table 7-14**. Although the $V=0.176$ illustrated in **Table 7-15** indicated only a small effect or practical non-significance between the two questions, it can be seen in **Table 7-15** that respondents that had an average score of 3 to 5 out of 5 in Question 14 (Pro-ecocentric worldview), 66.7% of them also indicate "yes" in Question 10.

Table 7-15: The correlation between Planners' environmental worldview and their consideration of ecological concepts.

Q14 WITH Q10	QUESTION 10: Which of the following concepts have you previously took into consideration in your planning activities? (URBAN ECOLOGY)			
QUESTION 14: Please indicate your level of agreement on the following items	OPTIONS	YES	NO	TOTAL
	1	0	0	0
	2	0	0	0
	3	12	4	16
	4	13	8	21
	5	3	2	5
	TOTAL	28	14	42
Pearson Chi-Square		Cramer's V-test		Cramer's V approximate significance
0.8142		0.1392		0.6655

Table 7-15 illustrates that while only a small correlation is found, findings indicate that Planners' with a more pro-ecocentric worldview also tend to consider ecological concepts in their planning activities. These finding could address the research gap identified by Wallhagen & Magnusson (2017:498) (c.f. literature investigation, Chapter 4) regarding the correlation between the environmental worldview of urban design professionals' (including urban planners) and their decision-making concerning the environment.

7.5 Conclusion

Based on the statistical analysis it could be concluded that the majority of the sample of South African urban planners have a moderate-to-low knowledge and comprehension of the ESs concept. It was however seen that the majority of planners were aware that it is important to plan for ESs. In terms of the multi-functionality concept, findings similar to those identified by Di Marino *et al.* (2019:644) and Hansen *et al.* (2017:43) in the literature investigation (c.f. Chapter 5) were found. The majority of the sample of planners were more familiar with the Multi-functionality as urban land-use concept, while Multi-functionality as a GI planning principle was less familiar to the respondents. Thus, identifying the potential need to increase knowledge of this concept among South African urban planners.

Findings on the integration of ecological aspects and concepts in South African planning activities indicated that the ESs concept is only sometimes specifically focussed on in planning activities. This result may be due to the moderate-to-low knowledge and comprehension of the concept reported. A significant finding from the quantitative investigation was the statistical correlation between how important respondents ranked the planning for ESs and how often they consider ESs in their planning activities. Further evidence from the chapter implies a general consensus among the respondents regarding the inclusion of these ecological aspects and concepts such as GI planning and urban ecology in the urban planning activities.

The chapter provided further evidence for the sample of South African urban planner's motives for considering ecological aspects and concepts in their planning activities. Considerable insight has been gained with 36% indicating the recommendation of a specialist, that emphasises the transdisciplinary interaction required to consider an ecological approach in urban planning activities (c.f. 2.3.1 and 5.4.3.3). 39% of the sample of planners indicating their own knowledge regarding the aspects and concepts as motive for considering it in planning practice. This once again, stresses that perceived knowledge of ecological aspects and concepts influence the attitude of planners towards the consideration of these concepts.

A further investigation on South African urban planners' incorporation of ecological concepts was based on the literature investigation findings presenting that a person's environmental worldview influences environmentally friendly approaches in planning projects. The study provides the first assessment of environmental worldviews among South African urban planners. An overall "ecocentric" environmental worldviews were reported among the sample of South African urban planners indicating that sample recognise that they have an ethical responsibility to the environment through co-development between nature and human activities.

SECTION C: INTERPRETATION SECTION

CHAPTER 8 – CONCLUSIONS

8.1 Introduction to the Chapter

The purpose of the following chapter is to draw research conclusions in accordance with the research objectives identified in Chapter 1 of the dissertation and based on the findings presented in both literature and empirical investigations. The conclusions are grouped thematically into five groups. **Table 8-1** represents these groups along with the research objectives and research conclusion related to each group.

Table 8-1: The structure for the research conclusions chapter.

CONCLUSION THEMES	RESEARCH OBJECTIVE (CHAPTER 1)	CHAPTER REFERENCE	CONCLUSION
Concluding on the interface between urban planning and urban ecology	To reflect on the interface between urban planning and urban ecology.	Chapter 2 Chapter 6 Chapter 7	Conclusion 1: The interface between urban planning and urban ecology is advantageous, but not well recognised.
Concluding on a comprehensive typology of GI elements possible for implementation in South African urban planning practice.	To outline typologies of GI according to various international and local authors (South African) in order to compose a comprehensive typology of GI elements for South African urban planning practice. To assess best practice examples, within a South African context, regarding ESs generated by the identified inventory of GI elements.	Chapter 3 Chapter 6	Conclusion 2: Current limitations exists in developing a comprehensive typology of green infrastructure elements possible for implementation in South African urban planning practice.
Concluding on interpreting and conceptualising the ESs concept within an urban planning context	To consider the terminologies and interpretations of the ESs concept and to conceptualise ESs in an urban planning context. To assess best practice examples, within a South African context, regarding ESs generated by the identified inventory of GI elements.	Chapter 4 Chapter 6 Chapter 7	Conclusion 3: The ecosystem services concept could be enhanced as part of mainstream urban planning practice. Conclusion 4: South African urban planners had a low-to-moderated level of awareness and knowledge about the ecosystem services concept influencing the current integration of the concept within urban planning practice.

CONCLUSION THEMES	RESEARCH OBJECTIVE (CHAPTER 1)	CHAPTER REFERENCE	CONCLUSION
	To determine which GI elements, advance multi-functionality.		
Concluding on utilising the multi-functionality principle as a strategic planning strategy to plan for ESS	To reflect on the multi-functionality concept in an urban planning context, as well as urban planning approaches to plan for multi-functionality. To determine whichever GI elements, advance multi-functionality.	Chapter 5 Chapter 6 Chapter 7	Conclusion 5: There is a definite connection between multi-functionality and ecosystem services. Conclusion 6: Multi-functionality as a GI planning principle is an optimal strategic planning strategy that could be utilised by planners to plan for ecosystem services.
Concluding on the state of an ecological approach in South African urban planning practice	To capture the general knowledge and considerations among urban planners regarding the ecological concepts (ecosystem services, green infrastructure planning and multi-functionality) in South African urban planning practice. To determine the environmental worldview among respondents as South African urban planners and relation to considering ecological concepts in South African urban planning practice.	Chapter 3 Chapter 4 Chapter 7	Conclusion 7: Inadequate knowledge regarding ecological aspects and concepts hinder the integration thereof in South African urban planning practice.

Source: Own construction (2020).

The conclusions drawn are based on a synthesis of results gained following the literature and empirical investigation chapters. The purpose of these conclusions is to reflect on each research objective, however, also for each conclusion not to be evaluated in isolation, but in the context with the broader research conducted. The before-mentioned themes and accompanied conclusions furthermore serve as the foundation for the recommendations made in the subsequent chapter (Chapter 9) and serve as point of departure to strengthen ecological approaches as part of mainstream urban planning.

8.2 Conclusion 1: The interface between urban planning and urban ecology is advantageous, but not well recognised.

When considering ecological approaches in contemporary urban planning practice it requires a holistic approach for urban planning practice of embodying different knowledge from other urban disciplines. This specifically includes the re-consideration of the environment, along with

comprehending data and knowledge from the urban ecology discipline. The first part of the research aimed to substantially conclude on the interface between urban planning and urban ecology (Chapter 2), while the application thereof was investigated in the empirical investigation (Chapter 6 & 7). Taken together, evidence from the literature and empirical investigation present the following:

1. Urban ecology forms part of urban planning (c.f. **2.3.1**) and planning practice does to a degree consider the incorporation of urban ecological knowledge (c.f. **7.4.2**). Results from the empirical investigation provided evidence on the application of urban ecology in urban planning practice with 67% of the sample of respondents indicating “yes” they do consider urban ecology in their planning activities. On the other hand, research regarding the incorporation of urban ecological knowledge into urban planning actions was however identified within the literature investigation as a challenging area for urban planning practice. Similar results were found in South African urban planning practice with 62% of the respondents’ presenting “lack of implementation strategies” as a challenge for the sample of planners to integrate urban ecological considerations within urban planning practices (c.f. **7.4.2.8**).
2. Generally, the results of the literature studies (Chapter 2 to Chapter 5) supported the idea of Green Infrastructure (GI) planning as the common ground to join urban ecological considerations and urban planning practice (c.f. **2.4**). In planning practice, GI is more than traditional natural conservation strategies but an instrument for urban planning practice that holds the ability to incorporate and plan for the environment through spatial planning principles (c.f. **2.4.2.1**). Grounded within the GI planning approach is urban ecological knowledge gathered from the urban ecological discipline regarding ecological functions and services. This was confirmed in the empirical investigation where 36% of the sample of planners agreed with “the recommendation of a specialist” to incorporate ecological considerations in planning practices (c.f. **7.4.2.7**). Specialists, such as urban ecologists, therefore, sets an important scientific foundation which could informs environmental planning practices. These results encourage future research on transdisciplinary teams in urban planning practice and specifically the importance of a partnership between planners and urban ecologists in the pursuit of quality urban areas.
3. The exploratory case-study investigation confirmed that it is possible to synthesis urban ecological knowledge with urban planning practice. Focusing on planning for GI elements, with the spatial planning principle of “multi-functionality” in mind, is presented as a way to target plan and directly integrate the ecological consideration of ecosystem services into urban planning practice (c.f. **6.6**).

This conclusion concludes by arguing that the above-discussed findings an interface was suggested where the two disciplines of urban planning and urban ecology meet and interact. The drawn conclusion is that the interface is a mutual benefit each discipline could contribute to one another. Predominantly, the urban ecology discipline provides, informs, and explains urban planning practice with ecological knowledge and considerations such as ESs to contemplate the environment in mainstream urban planning practices. (c.f. **2.3**). Whereas the recent ecology “for” cities perspective inquired in the literature study (Chapter 2) a more action-based practice to urban ecological knowledge (c.f. **2.3.1**). This research confirmed that urban planning practice holds the ability to achieve in the ecology “for” cities perspective by directly incorporating and applying this urban ecological knowledge (c.f. **6.6**). The interface where these two disciplines meet and present mutual benefits is through the GI planning approach and the GI spatial planning principles of “connectivity and networks”, “multi-functionality”, “integration” (of people, places, and policies), “social inclusion”, and the principle of “long-term strategies” (c.f. **Table 2-2**). This study provides a point of departure for research on how urban ecology could be utilised by planners to plan for sustainable cities. The research has also gone some way towards providing planners with a deeper insight that it is possible to integrate urban ecological knowledge with spatial planning principles. The approach to combine urban ecological knowledge with spatial planning in South African is through the GI planning approach.

8.3 Conclusion 2: Current limitations exist on a comprehensive typology of green infrastructure elements possible for implementation in South African urban planning practice.

In an attempt to outline typologies of GI according to various international and local authors (South African) the following can be concluded.

A GI typology can be described as a classification of GI element (green space) categories possible for implementation in urban planning practice. Literature investigation findings underscore the complexity and diversity in the GI element typology debate (c.f. **3.3.2**). Considerable progress has been made with developing a variety of international GI typologies (c.f. **3.3.1**). However, a universal typology is unrealistic seeing the natural conditions and social demands present in different countries. In the local South African context, a variety of GI elements are mentioned within the South African literature (c.f. **3.3.2**), however, a lack of studies exists on classifying GI elements into a comprehensive typology within the South African context. The research attempted to fill the gap by expanding on the available South African typologies founded within the South African literature (c.f. **Table 3-2**) by:

1. Considering opportunities for GI elements mentioned by South African, as well as other (international) literature to construct the inventory of GI elements (**Literature investigation**).
2. Exploring best practice examples (case-studies) based on the inventory of GI elements. All the best practice examples (case-studies) were selected as they had the characteristic of generating numerous ESs, as well as were spaces that contribute to the quality of their urban environment where they occur. The cases were selected according to the **criterion sampling**, and **purposeful sampling** techniques (c.f. **6.3.1**). This means that each case selected represented a GI element of the predetermined inventory of GI elements; is located within South African; and yield the most significant information and knowledge regarding each GI element. The research was however limited with a shortage of data, including case studies capturing GI elements in a South African context (c.f. **6.3.1**) (**Empirical investigation**).

Combining findings from the literature and empirical investigation the following value could be added to the urban planning practice:

- (i) This research results have the potential to build on and expand the existing South African GI typology seeing that identified gaps of GI elements within the existing South African typologies (c.f. **3.3.2.2**) were attempted to be fulfilled. These gaps were filled by considering GI elements emphasised and discussed by South African literature (c.f. **3.3.2.2**), as well as other GI elements gathered from the international GI typologies (c.f. **3.3.1**).
- (ii) While preliminary the typology inventory (c.f. **Table 3-3**) might inform and be of assistance to South African urban planners to familiarise them with comprehensive GI elements to facilitate implementation.
- (iii) The inventory was further complemented with implemented best practice examples of the South African GI elements (c.f. **Table 6-2**). The best practice examples are case-specific and some other GI element examples could have been chosen. The chosen examples ultimately serve to represent a point of departure reflect on the GI elements in order to enhance recognition and future implementation thereof through South African urban planning practice.
- (iv) The research has ultimately provided a deeper insight into the expanding field of GI research in the South African context by underlining a variety of organised and evidence-based South African GI elements. Future research should specifically consider context-focused and solutions for South African urban planning practice.

8.4 Conclusion 3: The ecosystem services concept could be enhanced as part of mainstream urban planning practice.

The purpose of the investigation regarding the ESs concept was to consider the terminologies and interpretations of the concept and to conceptualise this within an urban planning context (c.f. 1.3). The literature investigation confirmed that comprehending terminologies and emphasising the benefits of planning for ESs is a starting point to encourage urban ecological considerations such as ESs in urban planning practice (c.f. 4.6). The literature studies further indicated that for urban planners to fully comprehend and consider the ESs concept in an urban planning context a distinction should first be made between the various ESs categories and their accompanied ESs. The literature investigation in Chapter 4 provided a broad overview of the wide variety of ESs and the four ESs categories. Based on these results an ESs “knowledge-foundation” was created for urban planning practice (c.f. Table 4-2) and could be of interest to an urban planning audience who may not be familiar with the ESs concept. In addition, the empirical findings in this study provided further insight into the ESs knowledge-foundation by investigating the ESs provided by different GI elements (c.f. Table 6-23) (empirical investigation). These findings complement the earlier study of Hansen *et al.* (2017:34) that stated that to enhance ESs in planning practice the ESs generated from GI elements must be emphasised and compiled into an “inventory” that could aid decision-making and GI planning (c.f. 5.5). Table 8-2 captures certain conclusions drawn regarding the ESs knowledge-foundation.

Table 8-2: Findings on the ecosystem services concept in an urban planning context – knowledge foundation.

REFERENCE	CHAPTER REFERENCE	FINDINGS ON THE ECOSYSTEM SERVICES CONCEPT CONCEPTUALISED IN An URBAN PLANNING CONTEXT
Literature investigation	Chapter 5	A meaningful link exists between ESs and planning for GI elements.
Empirical investigation	Chapter 6	Correlating with the exploratory case-study analysis (section 6.4 and section 6.5) it could be concluded that a meaningful link exists between planning for the GI elements and ESs. GI elements have the ability to generate ESs.
Literature investigation	Chapter 5	A conceptual linkage exists between ESs and planning for multi-functional spaces. ESs could be utilised by planners to operationalise multi-functionality.
Empirical investigation	Chapter 6	Evidence from the exploratory case-study analysis indicated that ESs endorse the multi-functionality of a space.

Source: Cross-reference section 2.4, section 4.3, section 5.4.3.2, section 6.4, and section 6.5.

Besides equipping planners with knowledge about ESs, findings from the literature and empirical investigation (Table 8-2) pointed towards the idea to link the ESs concept in urban planning practice with the existing planning approach, such as planning for GI elements and emphasising the GI planning “multi-functionality” principle. The principle of multi-functionality should be utilised as the spatial strategy to link the ESs concept with urban planning practice (c.f. 5.4.3.2).

The literature investigation also incited that incorporation of the ESs concept in an urban planning context strongly depends on the comprehension and importance that ESs are provided in urban planning practice (c.f. 4.6.1).

8.5 Conclusion 4: The sample of South African urban planners present a low-to-moderate level of awareness and knowledge about the ecosystem services concept influencing the current integration of the concept within urban planning practice.

The investigated sample of South African planners indicated that it is “very important” or close to “very important” to plan for ESs. However, only a small portion of the planners always consider planning for ESs (c.f. 7.5). The majority of the sample of planners claimed they only plan for ESs “sometimes”. It was further alarming to see that 41.7% of the planners with 4 years or less experience was the majority group to consider planning for ESs as “unimportant”. Similar to literature findings (Chapter 4), the research evidenced that the ESs concepts ultimately depend on the comprehension and importance it is appointed to in urban planning practice. It was discovered that when planners considered ESs as important, they also indicated considering it in their planning activities. An identified gap was evident regarding the awareness and knowledge of South African sample of urban planners regarding the ESs concept.

The research intended to capture the general knowledge and considerations among planners regarding the ESs concept in South African urban planning practice (c.f. 7.4.2). Based on the literature investigation findings, ESs could be described as: *“the benefits all living species (especially humans) derive, directly or indirectly, from the capacity (function) of ecosystems to provide goods and services that satisfy needs”* (c.f. 4.3). This definition was employed as a barometer to determine the sample of South African urban planners understanding of the ESs concept (c.f. 7.4.2.2). The research found a general low-to-moderate knowledge and comprehension of the ESs concept amongst the majority of the sample of South African urban planners. As a result, the sample of planners were also only familiar with certain ESs categories. For instance, the regulating ES category was found more familiar to the planners, while knowledge regarding the cultural and habitat and supporting ES categories were lacking (c.f. 7.4.2.3.5). The most curious results that emerged from urban planners’ knowledge about the ESs concept was that a great majority of the sample of planners mentioned examples of ESs as *green spaces*, for instance; ‘Bioswales’, “wetlands”, “open spaces”, “trees”, “natural water” and “water courses”, “permeability of soils”, “natural bush”, and “urban farming on rooftops”. This could indicate that the planners are familiar with the linkage between planning for these green spaces to generate ESs, however, the results were in line with the literature investigation findings that African urban planners still tend to struggle with poor awareness and a lack of knowledge regarding the full comprehensiveness of ESs (c.f. 4.6.3).

It could therefore be concluded that an overall awareness making campaign among planners of the importance of the ESs concept is still required and future practices should consider the need for further research, education, and training related to linking the ESs concept with existing planning approaches to ensure that ESs are carefully considered in urban planning practice.

8.6 Conclusion 5: There is a definite connection between multi-functionality and ecosystem services.

The results of the research confirmed a connection between multi-functionality and ESs. Results gathered suggests the connection has two directions. Firstly, it was found that ESs are an indicator for how multi-functional a space is. The literature investigation confirmed ESs could be utilised by planners to establish the multi-functionality of a space (c.f. **5.4.3.2**). Furthermore, in the empirical investigation, the multi-functionality of GI elements was determined according to the perspective of Hölting *et al.* (2019:124083) that multi-functionality depends on the numerous ESs categories (provisional, cultural, regulating, and habitat & supporting services) recognised within the GI element (c.f. **6.3.2**). Based on the ESs categories recognised within the GI elements the investigation confirmed that the more ESs categories are found within the space, the higher the levels of multi-functionality of the space (c.f. **6.5**). Elements such as the urban wetland and private home garden best practice examples indicated a significant number of ESs and also confirmed a high level of multi-functionality (c.f. **Table 6-24**).

Within the second direction of the connection between multi-functionality and ESs it was found that planning for the multi-functionality GI principle is equivalent to planning for ESs. The findings from the exploratory case-study approach emphasised that planning for multi-functional spaces is planning for spaces that provide high levels of ESs and different ESs categories (c.f. **Table 6-24**). The investigation found GI elements as overall multi-functional, providing more than one ESs category.

8.7 Conclusion 6: Multi-functionality as a GI planning principle is an optimal strategic planning strategy that could be utilised by planners to plan for ecosystem services.

In an urban planning context, the multi-functionality concept was discovered as a confusing concept with many potential implementation approaches. The literature investigation (Chapter 5) resulted in three different multi-functionality implementation approaches, including achieving multi-functionality by employing land-use planning, planning for multi-functionality of an urban landscape and multi-functionality through GI planning (c.f. **5.4**). Multi-functionality could be understood as planning for an urban space to its full potential by ensuring that the space provides multiple functions and benefits to both urban dwellers and the environment. In an attempted to

reach the broader research aim the research specifically reflected on the multi-functionality approach that considers ESs (ecological considerations). Findings from the literature investigation identified that multi-functionality as a GI planning principle has a stronger emphasis on the idea of generating ESs (c.f. **5.4.3.1**).

In general, the research has underlined multi-functionality as a principle of GI planning as a strategic planning principle rooted in the planning of GI elements that aims to enhance the delivery of multiple environmental, economic, and social benefits by means of a single GI element (c.f. **5.4.3.2**). In line with this, the multi-functionality principle emphasizes that planning for green spaces is looking beyond planning for only for “conventional mono-functional undeveloped open spaces”, instead it is planning for spaces that have the capacity to have different and sometimes simultaneous functions and ESs and could serve a variety of needs (c.f. **5.4.3.2**). The investigation of multi-functionality as GI principle has further indicated that the aim of the principle should be combined with the following planning strategies (c.f. Ahern, 1997; 2007; 2011) (c.f. **Table 5-2**):

- **Offensive or opportunistic strategy:** planning for new multi-functional spaces through; 1) combining functions, 2) stacking, 3) time shifting.
- **Protective strategy:** employing preventative actions to preserve existing multi-functional GI elements.
- **Defensive strategy:** measures to defend (protect) existing multi-functional GI elements that are under development constraints and pressure.

A synthesis of the findings on the multi-functionality of GI elements is captured in **Table 8-3**. The table further suggests a possible planning strategy to plan for the multi-functionality of each GI element, based on the above-mentioned offensive or opportunistic, protective, or defensive strategies.

Table 8-3: Synthesis of the multi-functionality of GI elements and planning strategies to achieve this multi-functionality.

GI ELEMENTS	MULTI-FUNCTIONALITY LEVEL	POSSIBLE PLANNING STRATEGY
Green wall	Low	Offensive or opportunistic
Green roof	Medium	Offensive or opportunistic
Sustainable urban drainage systems (Constructed wetland)	Medium	Offensive or opportunistic or defensive
Sustainable urban drainage systems (Rain garden)	Medium	Offensive or opportunistic
Community garden	Low	Offensive or opportunistic
Rooftop Farming	Medium	Offensive or opportunistic

GI ELEMENTS	MULTI-FUNCTIONALITY LEVEL	POSSIBLE PLANNING STRATEGY
Horticulture	Low	Defensive
Urban forest	Medium	Defensive or protective
Existing or remnant natural areas	Medium	Defensive or protective
Urban wetland	High	Defensive or protective
Urban river or stream	Medium	Defensive or protective
Urban parks	Medium	Offensive or opportunistic
Botanical garden	Medium	Defensive or protective
Golf course and other green sport facility (sports fields)	Low	Offensive or opportunistic
Child-friendly space	Medium	Offensive or opportunistic
Health clinic garden	Medium	Offensive or opportunistic
Private home gardens	High	Offensive or opportunistic
Riverbank greenery	High	Defensive or protective
Cemeteries or burial grounds	Mono-functional	-
Roadside or railway greenery	Mono-functional	-
Vacant land	Mono-functional	-

Source: Cross-reference section 2.4.2.1, section 5.4.3.2, and section 6.5.

Although the multi-functionality levels indicated in **Table 8-3** are case-dependent, the evidence from the research has attempted to provide a deeper insight into the multiple benefits of GI elements. The research findings contributed to a context-based framework to South African planners that GI elements are not a “luxury” but are rather essential to sustain the natural environment in order to let humans (urban dwellers) benefit from ESs. Future research should consider a comprehensive investigation of the opinion and demand of urban dwellers regarding multi-functional spaces and supplied ESs.

The upside of the conclusion is that aiming at achieving the multi-functionality principle is the optimal instrument for planners to strengthen the GI planning approach and a means towards integrating ESs within mainstream urban planning practice. One downside factor found within the research was that planners are still however not familiar with multi-functionality as a GI planning principle to provide multiple ESs within the same space. The understanding of multi-functionality among planners remains exclusively to planning for multi-functionality through the land-use concept (c.f. 5.4.1). Evidence suggests that planners firstly need to be familiar with the GI planning

approach and the incorporation thereof in order to recognise multi-functionality as a GI planning principle (c.f. 7.4.2.9).

8.8 Conclusion 7: Inadequate knowledge regarding ecological aspects and concepts hinder the integration thereof in South African urban planning practice.

This research set out to capture the general knowledge and considerations among South African urban planners regarding the ecological considerations (ESs, GI planning and multi-functionality) by employing a statistical analysis. An online questionnaire was circulated among 42 selected South African planners registered as planners at the South African Council for Planners (SACPLAN). Captured in **Table 8-4** is the three main sections and related questions the questionnaire was comprised of (a comprehensive summary of the questions is included in **Annexure 1**):

Table 8-4: The three main sections and related questions contained in the research questionnaire.

SECTION	QUESTIONS	
Section 1 <i>Demographical background data</i>	Question 1	Please indicate your sector of employment
	Question 2	Which professional registration (SACPLAN registration) applies to you
	Question 3	In which year did you receive your undergraduate degree
	Question 4	Please indicate your years of experience
Section 2 <i>Ecological perceptiveness data</i>	Question 5	How familiar are you with the concept of ecosystem services
	Question 6	Please define ecosystem services to the best of your knowledge
	Question 7	Please provide examples of ecosystem services
	Question 8	How would you rank the importance of planning for ecosystem services
	Question 9	How often do you consider ecosystem services in you planning activities
	Question 10	Which of the following concepts have you previously taken into consideration in your planning activities? a) Green Infrastructure planning b) Urban ecology
	Question 11	Why did you take these above-mentioned concepts into consideration
	Question 12	What challenges have you encountered in applying these concepts in planning practice?
	Question 13	Please indicate which ONE of the following phrases do you consider as the best definition for the concept “multi-functionality” of spaces
Section 3 <i>Environmental worldview data</i>	Question 14	The section compromises of one main question (Please indicate your level of agreement on the following 15-items) to determine the environmental worldview among planners.

Source: Own construction (2020).

Forty-two (n=42) responses were gathered from all the question, except for Question 6 where only 38 responses were recorded (c.f. 7.4.2.2). The most prominent findings from the questions mentioned above are captured in the following table (Table 8-5).

Table 8-5: Summary of the findings on the research questionnaire.

SECTION	QUESTIONS	FINDINGS
Section 1 <i>Demographical background data</i>	Question 1	79% of the respondents were employed in the private sector. 21% of the respondents were employed in the public sector.
	Question 2	86% of the respondents were registered as Professional Planners. 14% were registered as Candidate Planners. - None of the respondents were Technical Planners.
	Question 3	41% of the respondents received their degree after 2011. 12% received their degree between 2001 and 2011. 21% received their degree between 1991 and 2000. 26% received their degree before 1990.
	Question 4	29% of the respondents had less than 4 years of practical planning experience. 19% had between 5 to 10 years of experience. 9% had between 16 to 20 years of experience. 38% of the respondents had more than 20 years of experience.
Section 2 <i>Ecological perceptiveness data</i>	Question 5	- Approximately 10% of the respondents were “very familiar” with the ESs concept. 67% of the respondents ranked their familiarisation in between “very familiar” and “never heard before”. 24% of the respondents “never heard” of the ESs concept before.
	Question 6	32% of the respondents had a high level of similarity with the formulated definition of ESs. 37% had a moderated level of similarity. 32% of the respondents had a low-level similarity.
	Question 7	- Examples of all four ESs categories were mentioned by the respondents. 9 examples were mentioned related to the provisioning services category. 19 examples were mentioned related to the regulating services category. 5 examples were mentioned related to the cultural services category. 3 examples were mentioned related to the habitat and supporting services category.
	Question 8	88% of the respondents ranked planning for ESs as either as “very important” (n=19) or close to “very important” (n=18). 10% of the of the respondents ranked planning for ESs as either as “unimportant” (n=2) or close to “unimportant” (n=2).
	Question 9	17% of the respondents indicated they “always” considers ESs in their planning activities. 31% of the respondents indicated “sometimes”. 14% indicated they “never” considers ESs in their planning activities.
	Question 10	71% of the respondents indicated “yes” they have previously considered green infrastructure planning in their planning activities.

SECTION	QUESTIONS	FINDINGS
		• 67% of the respondents' indicated "yes" they have previously considered urban ecology in their planning activities.
	Question 11	• 39% of the respondents' indicated "own knowledge" as the reason for taking the concepts into consideration. • 36% of the respondents' indicated "the recommendation of a specialist". • 16% indicated "the result of public participation". • 9% indicated "client or tender stipulation".
	Question 12	• 67% of the respondents considered "financial limitations" as a challenge encountering the application of ecological concepts in planning practice. • 62% of the respondents considered "lack of implementation strategies" as a challenge. • 43% indicated "lack of knowledge regarding the concepts" as a challenge. • 26% indicated "lack of case studies regarding the benefits thereof" as a challenge.
	Question 13	• 71% of the respondents' indicated "multi-functionality as urban land-use concept" definition as the best definition for the concept "multi-functionality" of spaces. • 19% of the respondents" indicated "multi-functionality as the green infrastructure planning principle" concept as an agreeable definition for the "multi-functionality" of a space.
Section 3 Environmental worldview data	Question 14	The overall environmental worldview of South African urban planners was determined as: • An average score of 56.1 out of 75 indicated an overall pro-NEP or ecocentric worldview among South African urban planners.

Source: Own construction (2020).

To further analyse the findings presented in **Table 8-5**, selected questions were cross-tabulated and practically significant relationships were determined between the variables. The questions cross-tabulated are illustrated in

Table 8-6. The reasons for the cross-tabulations are also explained in the table below.

Table 8-6: Cross-tabulation between selected questions of the research questionnaire.

QUESTIONS CROSS-TABULATED	WHAT THE RESEARCH WISHED TO DETERMINE	FINDINGS (Cramer's V-test results & research contributions)
Q1 with Q10	To determine if planners in different sectors of occupation (public and private sectors) consider ecological concepts in urban planning practice differently.	a) The green infrastructure planning concept: • V~0.073: a small effect or practical non-significance • A low correlation was found between the frequency of considering the green infrastructure planning concept between planners in the public and private sector. b) The urban ecology concept: • V~0.246: medium effect or practical visible significance. • It was clearly that the public sector more often than the private sector considers the urban ecology concept in their planning activities.
Q1 with Q12	To determine if public and private sector planners indicated different challenges encountered in the application of ecological considerations in planning practice.	• V~ 0.132: a small effect or practical non-significance. • The most significant challenge identified by the sample of private sector planners were indicated as financial limitations. • The most significant challenge identified by the sample of public sector's planners was a lack of political will.
Q2 with Q8	To determine if different professionally registered planners ranked the importance of planning for ESs differently.	• V~ 0.127: a small effect or practical non-significance. • There was no real difference between the opinion of a Candidate planner or Professional planner when it comes to the importance of planning for ESs. • Most planners, regardless of their registration, agreed that ESs are important to plan for.
Q3 with Q5	To determine if the year planners received their undergraduate degree could have an influence on their familiarity with the ESs concept.	• V~ 0.285: medium effect or practical visible significance. • No clear correlation was indicated between planners' familiarity with the ESs concept and the year they received their undergraduate degree. • Planners where not very familiar with the concept, regardless of when they had received their undergraduate degree.
Q4 with Q9	To determine if planners' years of experience have a connection to their consideration of ESs in their planning activities.	• V~ 0.271: a medium effect or practical visible significance. • Results indicated that no matter the planners' years of experience, the majority of the sample of planners still considered planning for ESs as very important.

		The planners with 4 years or less experience was the majority group to consider planning for ESs as “unimportant”.
Q8 with Q9	To determine a correlation between respondents’ indication regarding the importance of ESs and how often they consider ESs in their planning activities.	V~ 0.426: a large effect or practical significance. - It was evident when planners considered ESs as important (Q8), they also indicated that they considered it in their planning activities (Q9).
Q10 with Q13	To determine if planners indicated “yes” in Question 10, did they also indicate the “multi-functionality as the green infrastructure planning principle” as the agreeable definition for multi-functionality?	V~ 0.325: a medium effect or practical visible significance - It was evident that the sample of planners which indicated “no” in Q10 also did not indicated in Q13 the “multi-functionality as the green infrastructure planning principle” as the best definition, while the 27% of the respondents’ that have chosen “yes” in Q10, also indicated the “multi-functionality as the green infrastructure planning principle” as the agreeable definition for multi-functionality.
Q8 with Q14	To draw conclusions regarding the sample of South African urban planners’ environmental worldview and if there is a connection with how important they ranked the importance of planning for ESs.	V~ 0.325: a medium effect or practical visible significance - Found that if the respondents had high score out of 75 (in order words an ecocentric worldview) these planners also consider ESs as important to plan for. - It was therefore found that the environmental worldview of planners is one of the influences on their perspective of how important it is to plan for ESs.
Q10 with Q14	To draw conclusions regarding South African urban planners’ environmental worldview and if there is a connection with considering ecological concepts in planning practice	V~ 0.176: a medium effect or practical visible significance. - A conclusion could be drawn that the sample of planners with a more pro-ecocentric worldview also tended to consider ecological considerations in their planning activities.

Source: Own construction (2020).

Findings gained were utilised to compare, build on, or to further inform the findings in the literature investigation. As seen in the research problem statement, (c.f.1.2) while international studies have investigated the general knowledge and considerations among urban planners regarding the ecological aspects and concepts before (c.f. Albert *et al.*, 2014; Mascarenhas *et al.*, 2014; La Rosa, 2019), a comprehensive study on South African urban planners’ general knowledge has not yet been conducted. Therefore, this research has gone some way towards enhancing the understanding of the knowledge and integration of ecological aspects and concepts in South African urban planning practice.

Findings on South African urban planning practices found that the ecological aspects and concepts may not be sufficiently implemented by planners. The results of the statistical analyses indicated that planners in the different sectors of occupation (private and public sector), their professional registration, or their years of experience do not have any correlation with the

integration of ecological considerations in their planning work. Other challenges identified by the sample of planners were challenges such as financial limitations and a lack of implementation strategies (**Table 8-5**). Another interesting finding was that the frequency of integrating ecological considerations is depended on the importance these ecological considerations are provided by the planners.

While some authors argue that the environmental worldview of planners could have an influence on considering ecological concepts in South African urban planning practice, no one as far as knowledge exists, has studied this specific area within the South African urban planning practice (c.f. **7.4.3**). The results of this research's environmental worldview investigation indicated that the environmental worldview of the investigated sample of planners is one factor that have an influence on their perspective on incorporating ecological considerations. This research argues that "knowledge" is the main motive behind the given importance to ecological considerations. Ultimately, this perceived knowledge influences the attitude of planners towards considering and integrating it in practice. Finding in terms of the level of perspective and knowledge South African planners have about ecological considerations was concluded in line with the literature investigation findings. The majority of the South African urban planners included in the sample only had a moderate-to-low knowledge of the ecological aspects and concepts.

It is therefore reasonable to conclude that the reason why planners do not include ecological aspects and concepts such as ESSs, GI planning, and multi-functionality is not that they have "wrong environmental worldviews" but that they do not have adequate knowledge of the ecological aspect's concepts and knowledge regarding implementation strategies to incorporate these considerations into mainstream urban planning practice. Similar results were found in the study of Huston (2017) and Cilliers (2019a) that studied the current application and implementation of the GI concept in South African planning practice and found that the current use of GI in practice is very limited predominantly because of a misconception, inadequate GI education, as well as a lack of "know-how-to" knowledge pertaining GI (c.f. **3.3.2**). These findings highlighted the need to increase the knowledge of the South African urban planners regarding ecological considerations, as well as the opportunity to construct some implementation strategies in order to include these considerations in broader planning activities.

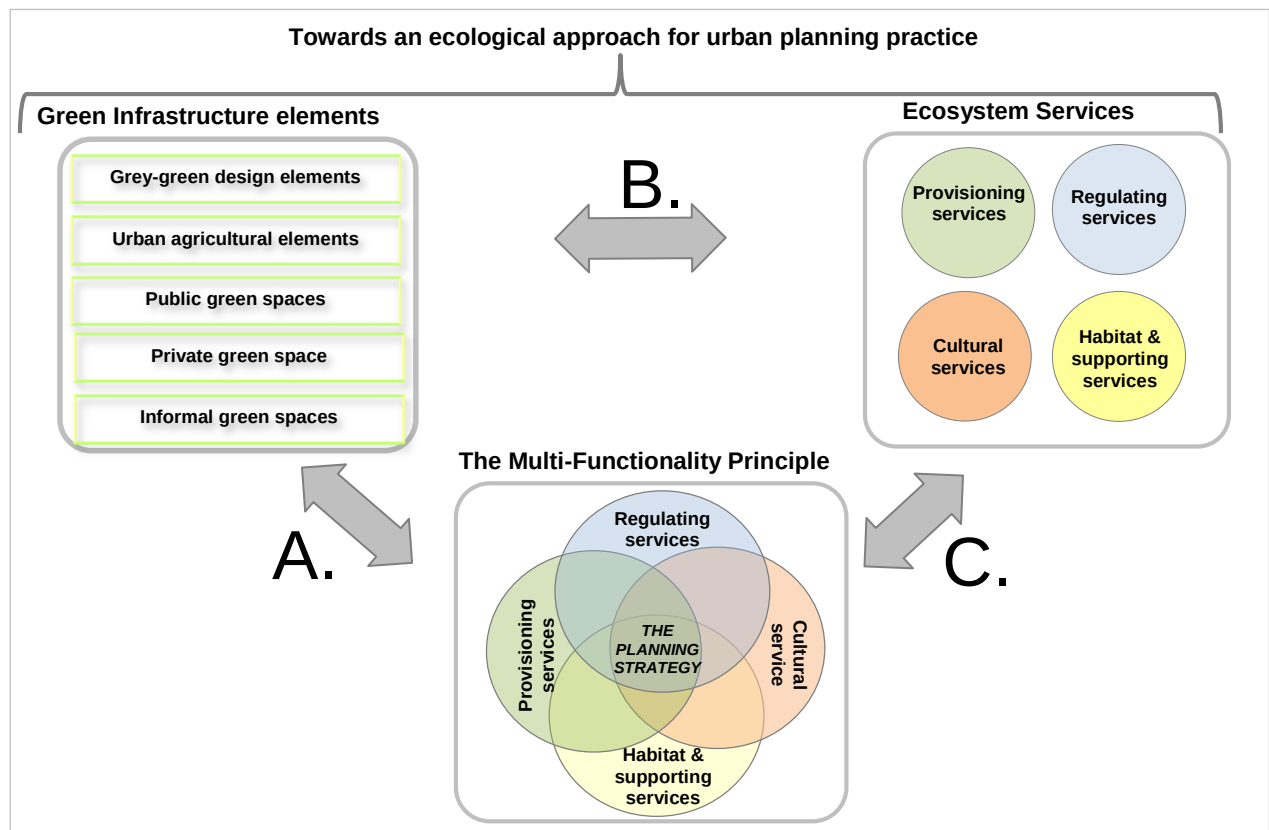
8.9 Concluding the dissertation

Based on the literature and empirical investigation of the previous chapters, the research objectives as stated in Chapter 1 were addressed and concluded in this chapter. This research has made an important contribution towards the South African urban planning context when

attempting to investigate ecological considerations such GI, multi-functionality and ESs from an urban planning perspective.

From the discussions in this chapter, the dissertation ultimately concludes that towards an ecological approach in mainstream urban planning practice, a connection exists between these ecological considerations. The connection is illustrated in **Figure 8-1** and elaborated upon accordingly.

Figure 8-1: Concluding on the nexus between ecological considerations within an urban planning context.



Source: Own construction (2020).

Figure 8-1 illustrates the following findings:

- A.** **Section 8.2** of the conclusion Chapter brought about GI and the GI spatial planning principle of multi-functionality as the urban planning instrument for planning practice to integrate ecological considerations through the planning for GI elements (c.f. **8.3**). These GI elements could be strategically selected, planned for, and managed to optimise and generate ESs benefits.
- B.** Subsequently, in **Section 8.4** a meaningful link was identified between planning for GI elements and ESs. GI elements have the ability to generate a number of ESs and are

therefore specifically designed and managed to deliver a wide range of ESs. The fulfilment the ESs provides to GI elements is strengthens the role of the elements, ensuring that the elements are of a certain quality, and ultimately indicating that they are not a “luxury good” but are rather as essential as other infrastructures in urban areas to sustain the natural environment and for humans (urban dwellers) to benefit from ESs.

- C.** The research concluded on a connection between ESs and the multi-functionality principle in two directions; 1) ESs are the indicator for the multi-functionality of space, and 2) planning for multi-functionality in GI is equivalent to planning for ESs (c.f. **8.6**).

Indicated by **Figure 8-1**, the dissertation thus concludes that the multi-functionality principle links GI planning and ESs. The core of the multi-functionality principle is that it is a spatial planning principle with the potential to guide urban planning practice by integrating both urban planning practices (GI planning) and ecological considerations (ESs). Ultimately, the multi-functionality principle guides strategic planning towards planning for ESs as the basis for an ecological approach for urban planning practice.

South African urban planners are however not yet including these ecological considerations in mainstream planning sufficiently as they are not up to date with enough knowledge regarding these ecological considerations. The following chapter will endeavour to identify planning recommendations to guide planning practice to ecological considerations as means towards strengthen ecological approaches as part of mainstream urban planning.

CHAPTER 9 – PLANNING RECOMMENDATIONS

9.1 Introduction to the Chapter

The following chapter provides recommendations for the planning profession based on the conclusions presented in the previous chapter.

Figure 9-1, the chapter consists of five recommendation sections set for the planning profession, which are thematically connected to the seven conclusions drawn in Chapter 8. The development of the recommendations includes three instruments: 1) planning practice related recommendations, 2) further planning research-related recommendations, and 3) planning education or further training related recommendations for each of the five recommendation sections.

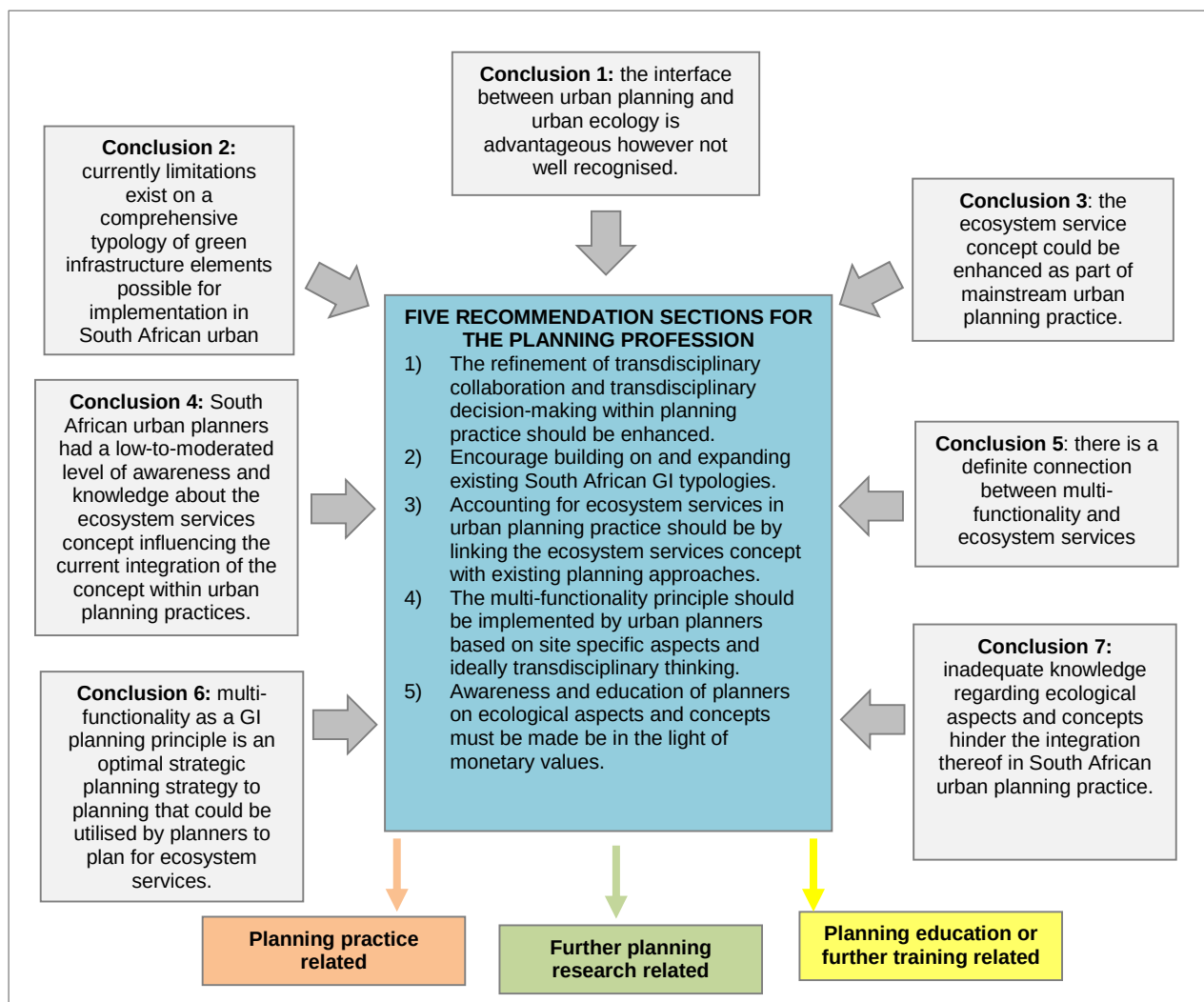


Figure 9-1: The development of planning recommendations based on the conclusions drawn in the research.

Source: Own construction (2020).

9.2 Recommendation 1: The refinement of transdisciplinary collaboration and transdisciplinary decision-making within planning practice should be enhanced.

The conclusion drawn on the interface between urban planning and urban ecology (c.f. **8.2**) underscored the need for transdisciplinary collaboration between the urban planning and urban ecology disciplines. Information and knowledge from the urban ecology discipline forms an important foundation for the implementation of ecological approaches as part of mainstream urban planning practice. The idea of incorporating ecological considerations in planning practice has further brought the need for planning practitioners to discard the disciplinary silos of conventional planning practice. Recommend approaches towards the recommendation are proposed in **Table 9-1** in order to enhance the interface between urban planning and urban ecology within urban planning practice.

Table 9-1: Recommendations to the refinement of transdisciplinary collaboration and transdisciplinary decision-making within planning practice.

Instruments to the recommendation		Recommend approach	Cross-reference
Planning practice	Facilitate a transdisciplinary team	Involve researchers and practitioners from both disciplines (urban planning and urban ecology), along with other urban disciplines (e.g., engineers, landscape architects), government officials (e.g., local government officials) and a strong public participation component. Planning practice should create the common ground where the transdisciplinary team could gain mutual benefits from one another by combining specialist conceptual ideas, skills, and knowledge and decide on the best possible implementation strategy.	5.4.3.3
	The inclusion of recommendations of a specialist and integrated thinking approaches	Planning practice should enhance the necessity of having an urban ecologist on their team when planning for ecological considerations. The aim would be to organise a science-practice collaboration foundation where urban ecologists provide for example the baseline scientific ecological data on benefits and opportunities of GI and planners the practically implementation of the scientific data through the spatial planning principles of “connectivity and networks”, “multi-functionality”, “integration” (of people, places and policies), “social inclusion”, and the principle of “long-term strategies” (c.f. Table 2-3).	7.4.2.7

Instruments to the recommendation		Recommend approach	Cross-reference
Further planning research	Future research on transdisciplinary teams within urban planning practices and specifically the importance of a partnership between planners and urban ecologists should be further investigated	More research on a transdisciplinary working method for urban planning practice, along with a model of activities and which actors are responsible for which activities (c.f. Ahern <i>et al.</i> , 2014). It can also be investigated how this proposed working method and model will fit into and refine other transdisciplinary models such as City Labs as in Cape Town (Andersen <i>et al.</i> , 2013) and Johannesburg (Bobbins & Culwick 2015) and a research action partnership as in Durban (Cockburn <i>et al.</i> , 2016; Taylor <i>et al.</i> , 2016).	5.4.3.3 7.4.2.7
Planning education or further training	Interpret the urban ecological science for urban planners.	Stronger emphasis on educating urban planners on the work of urban ecologists and to be familiar with how to interpret the scientific language and data utilised by the urban ecology discipline. Higher planning education curricula should therefore include modules and education programmes that ensure planners have sufficient knowledge on the urban ecology discipline and the skills to facilitate transdisciplinary collaboration between the two disciplines. In the same line, short courses and training programmes should be hosted for practicing planners as part of their continuous professional development (CPD).	2.3

Source: Own construction (2020).

The research thus encourages, as posed in **Table 9-1**, transdisciplinary teams along the lines of City Labs and research-action partnerships, future research on activities within these transdisciplinary teams, and specifically the importance of a partnership between urban planners and urban ecologists within the larger transdisciplinary team.

9.3 Recommendation 2: Encourage building on and expanding existing South African GI typologies.

As South African cities have unique natural conditions (geomorphological, climatic, biological), historical backgrounds, and social demands, a context-based GI typology are required for implementation. As seen in the research conclusions, the opportunity exists to construct an official **comprehensive** typology of GI elements possible for implementation in a South African context. This research recommends building on and expanding on existing South African GI typologies through the following recommended approaches (**Table 9-2**).

Table 9-2: Recommendations to encourage building on and expanding existing South African GI typologies.

Instruments to the recommendation		Recommend approach	Cross-reference
Planning practice	Development of local green infrastructure (GI) registers	To develop context-based municipal GI “registers” that captures localise implemented GI elements. The goal of such a register could guide local planning in identifying a city’s current state of GI typologies, in order to maintain the existing GI elements, and to recognise potential opportunities or gaps for upgrading and implementation of new elements. This could furthermore be included and considered in the strategic planning frameworks of local municipalities.	3.4
Further planning research	Identify and document best practice case-studies on South African GI elements.	From the exploratory case-study investigation it was evident that case-studies documented on best practice South African examples of GI elements are lacking the identified best practice examples captured in this research could provide a valuable point of departure, however, more detailed and documented best practice examples are required. More information on best practice GI elements would help inform and influence South African urban planning practice on GI elements possible for implementation. Also, consideration should be given to case-studies in different urban-contexts within South Africa, for instance best practice examples of GI elements in small-and-medium size cities, townships, and informal settlements.	3.4 Table 6-2 8.3
	Research on the further refinement of South African GI typology	Further classifying the GI elements captured in this research should be captured according to size and scale, main ESs category, location, or surface coverage. This research could especially assist planning practice with deciding on which GI elements would be suitable for a current location or specific needs.	3.3
Planning education or further training	Educate planners on contextualising GI elements for a South African context.	Encourage educating future urban planners with the necessary skills to acknowledge South Africa’s unique context (also the natural aspects) and provide them with the knowledge to contextualise and implement international GI elements within a South African context.	3.3
	Local government officials, clients and the public sector should be made aware of all the GI elements possible for implementation, as well as the benefits (ESs) generated by these elements.	Restraints identified that local planning practice currently follows an approach regarding GI elements as “luxury” or a “visual attribute” and not yet as a necessity. Greater efforts are necessary to ensure those included as part of transdisciplinary teams are familiar and informed on the variety of GI elements possible for implementation and the benefits of implementation thereof, through for example host briefing sessions and conferences.	3.3 Table 6-23

Source: Own construction (2020).

9.4 Recommendation 3: Accounting for ecosystem services in urban planning practice should be by linking the ecosystem services concept with existing planning approaches.

Table 9-3 recommends that accounting for ESs in urban planning practice should be done by linking the ESs concept with existing planning approaches. The table provides both planning practice and further planning research recommendations, as well as some planning education or further training recommendations as instruments to accomplish the recommendation in the planning profession.

Table 9-3: Recommendations on linking the ecosystem services concept with existing planning approaches.

Instruments to the recommendation		Recommend approach	Cross-reference
Planning practice	Align ESs with an urban planning issue or objective.	It is recommended that ESs might be considered by planners as a possible solution, benefits or mitigation strategy to specific planning issues or objectives. The issues and objectives should each be considered context-specific when alignment with specific ESs. For this context-specific consideration it is recommended to follow the six-step methodology presented by TEEB (2011) on ESs decision-making (c.f. 4.6.1) to align ESs with a specific planning issue or objective. An example of how the six-steps approach could be approached by planners' follows: Step 1: identify the problem or planning objective that requires attention by consulting various stakeholders (e.g., officials, general public, community groups and volunteers). Step 2: gather information on if the problem could be resolved through planning for ESs. Then identify the ESs central to or on which the problem or objective depends on. Step 3: decide on a qualitative or quantitative assessment method for the assessment and gathering of information on the ESs. Step 4: implement the assessment method in practice and determine how the ESs could benefit the problem or support the planning objective. Step 5: compare different options and choose the most useful one to address the problem or planning objective, for instance, choosing the specific GI element that generates the ESs to resolve the urban issue. Step 6: investigate the impact (negative or positive) of the decision on a range of stakeholders.	4.6.1
	Utilise ESs as an indicator for GI planning.	Utilise ESs as an indicator for quality GI planning. This could for instance be combined with the "Development of local green infrastructure registers" recommendation mentioned in Table 9-2. Spatially identifying geographical areas (e.g., GI elements) and their ESs, such as researched in this study, could indicate the quality of the area or GI elements and the extensive reliance for humans and urban areas on such GI elements to draw benefits from. Evidence could ultimately encourage and coordinate decision-making to protect and enhance GI elements which provides these ESs. Vice Versa, ESs could also be utilised as an indicator to plan for specific GI element to fulfil a certain function or in specific urban needs.	6.4.7

Instruments to the recommendation		Recommend approach	Cross-reference
Further planning research	Research on planning for ESs within a South African context should shift towards investigating a strong public participation approach	It is recommended that future research should investigate the demand side of ESs, or in other words the needs of humans (urban dwellers) towards specific ESs. The focus should especially be whether if socioeconomic factors, and demographic aspects such as age and ethnicity that could influence human need and demand differently to specific ESs. South Africa offers an interesting opportunity to examine different ESs needs among different socio-economic groups (Gwedla & Shackleton, 2019:245). Such research would require a strong public participation approach to identify needs. The participation and results would be useful to the required transdisciplinary team, as recommended in Table 9-1 .	4.6.3
	Transdisciplinary research on developing a standardised ESs assessment tool for planning practice.	The following recommendation is made on Step 3 of the six-step approach methodology represent by TEEB (2011) on ESs decisions-making. The ESs assessment form a part of the planning decision-making process. It is therefore suggested to work together with transdisciplinary stakeholders on methods and tools for assessing ESs that would provide easy understandable and relevant information regarding ESs to urban planners as the basis for local planning decisions.	4.6.1
Planning education or further training	Continuous efforts on educating planners on ESs and encouraging them to be more open to adopt the concept in urban planning practice.	Evidence on the sample of South African planners indicated that younger planners (4 year or less practical experience) were the majority group to rank ESs as “unimportant”. A suggested action is to educate young planners as soon as possible on the importance and benefits of ESs. Continued efforts are needed on educating planners on the various ESs categories and their accompanied ESs, as well as equipping planners with the skills to implement ESs through existing urban planning approaches. Therefore, higher planning education curricula should keep striving at including planning approaches such GI planning and the application thereof, as well as other approaches recommended in this table. Research however indicated that professional planners already within planning practice are also not familiar with the ESs concept, therefore, further learning opportunities should also be encouraged to equip these planners with the necessary knowledge and skills. Interactive methods, such as workshops, are recommend informing and equip these planners.	4.6.1 7.4.2.4

Source: Own construction (2020).

9.5 Recommendation 4: The multi-functionality principle should be implemented by urban planners based on site specific aspects and ideally, transdisciplinary thinking.

It was concluded in Chapter 8 that the multi-functionality principle provides urban planners with the potential to plan for ESs (c.f. **8.7**). The research ultimately recommends that the principle should be site specific and ideally transdisciplinary to effectively plan for ESs. **Table 9-4** proposes planning profession related recommendations on how to consider the multi-functionality principle site specific and transdisciplinary.

Table 9-4: Recommendations on implementing the multi-functionality principle based on site specific aspects and ideally, transdisciplinary thinking.

Instruments to the recommendation		Recommend approach	Cross-reference
Planning practice	Provision and demand for different ESs should be utilised as an additional tool for the assessment of multi-functionality.	The research concluded in section 8.5 that the multi-functionality principle aims at planning for spaces that have the capacity to have different and sometimes simultaneous ESs and could serve a variety of needs. This research provided a basic framework for assessing multi-functionality according to ESs and ES categories and emphasises that such an assessment should be done at a site-specific scale, depending on the type of GI elements, the urban context, and according to the method of assessing the ESs. In line with site specific assessment of multi-functionality there further remains the opportunity to assess multi-functionality concerning the part of the multi-functionality principle to “serve in a variety of needs” . The principle is linked to human demand and site-specific assessment should therefore further incorporate a strong public participation component when planning for multi-functional spaces. This could be done through a “need-assessment approach” The assessment considers how the current green spaces meet the needs of the community and how green spaces then could be improved (Çetinkaya, 2014:16) to ultimately contribute to a sustainable environment for urban residents (Boulton <i>et al.</i> , 2018:97). This could especially aid planners to identify areas where multi-functionality requires further enhancement or where an area requires specific promoting of ESs according to a community’s need.	5.4.3.3 6.5 8.6
	The multi-functionality principle might be considered as a guide towards quality green spaces in planning standards.	As the multi-functionality principle provides the opportunity to strengthen the role of green spaces in urban areas and to ensure that green spaces are sustainable it is recommended that a reasonable approach to urban planning practice to plan for quality green spaces is to utilise the multi-functionality principle as standard and guideline. Based on the research findings on the multi-functionality principle, the research recommends, for both conservation and planning of new GI elements, to follow the following checklist contemplated: ☑ Is there a synergy between multiple ecological, social, and economic functions of the green space to enhance the ecological, social, and economic benefits of the green space (c.f. Table 5-3)? ☑ Are green resources combined with other forms of urban infrastructure (e.g., planning for GI elements such as green roofs, green walls, and sustainable drainage systems)? ☑ Does the green space highlight delivering multiple ESs categories (e.g., provisioning, regulating, cultural and habitat and supporting services)? Following Step 2 of the six-step methodology presented by TEEB (2011) on ESs decision-making (c.f. 4.6.1 and Table 9-3) to identify relevant ESs from each ESs category. ☑ Did the planning for the green space build a common ground for multiple disciplines (e.g., urban planners, engineers, landscape architects, ecologists) and other departments (e.g., current local governance authorities and planning structures) in collaboration with non-governmental stakeholders (e.g., public, and private landowners, voluntary organisations, as well as individuals and communities) to share options and ideas?	5.4.3

Instruments to the recommendation		Recommend approach	Cross-reference
Further planning research	Further research should be encouraging regarding implementation strategies for multi-functionality in strategic planning.	Research from this study identified the planning strategies of offensive or opportunistic, protective, and defensive (c.f. Ahern, 1997; 2007; 2011) as the strategic planning strategies to achieve multi-functionality. More information is required on implementation examples of the offensive or opportunistic, protective, and defensive strategies as the essential next step in securing the multi-functionality principle in mainstream urban planning practice. This once again requires the need for transdisciplinary collaboration with expertise such as Urban ecologists and other disciplines (Table 9-1). Further research will be useful to specifically explore local context (South African) viewpoints for the offensive or opportunistic, protective, and defensive strategies possible for implementation through South African urban planning practice.	Table 2-3 5.4.3.2 5.6
Planning education or further training	Encourage education on the benefits and opportunities of the multi-functionality principle.	This research contributed to the planning profession by studying the common interrelations between multi-functionality and ESs. More planners should be made aware of this nexus between multi-functionality and ESs. It is therefore recommended that curriculum of higher planning education should continue efforts on educating planners on GI planning and more specifically on the GI spatial planning principles.	5.4.3

Source: Own construction (2020).

9.6 Recommendation 5: Creating awareness and educating planners on ecological aspects and concepts must be made in the light of monetary values.

The current science- practice-gap identified is the lack of knowledge and awareness of the role and importance of ecological concepts and aspects in urban planning practice. Some of the recommendations made in **Table 9-5** links back to some of the previous recommendations made on the ecological concepts and aspects in the previous sections. Along with these recommendations of transdisciplinary collaboration and transdisciplinary decision-making (c.f. **Table 9-1**) the research recommends creating awareness and educating planners on ecological aspects and concepts in the light of the monetary or the financial angle of these ecological considerations. **Table 9-5** details on the recommendation on considering the monetary value to create awareness regarding ecological aspects and concepts in urban planning practice.

Table 9-5: Recommendations on creating awareness and educating planners on ecological aspects and concepts in the light of monetary values.

Instruments to the recommendation		Recommend approach	Cross-reference
Planning practice	Unique context-based challenges should be taken into consideration.	Ecological aspects and concepts are often undervalued. From the survey-based research, it was evident that financial limitations were a context-based challenges raised by the sample of South African planners. Therefore, more detail is needed on linking ecological considerations with financial values. The benefits of ecological considerations should be linked with an economic or financial “Rand” value to encourage the inclusion of such considerations in the financial decision-making proses of local governments as was attempted for Durban (Roberts <i>et al.</i> , 2005) and Cape Town (TEEB 2011, De Wit <i>et al.</i> , 2012).	7.4.2.8
	Planning still has to do more - “new ways of doing things”: re-scoping of urban planning practices.	To become more “ecological” in planning decision-making and processes entails to incorporate ecological knowledge and new strategies which are not yet necessarily considered as a priority in mainstream urban planning. Linked with the recommendation “The inclusion of recommendations of a specialist” (Table 9-1). The “knowledge-foundation” created throughout this research for urban planning practice could be used to develop targeted interventions aimed at re-scoping urban planning practice towards an ecological approach.	5.4.3.3
Further planning research	Research on cases for improving knowledge and awareness regarding ecological aspects and concepts in urban planning practice.	Learning from international cases, approaches, implementation, and education strategies and experiences on what works and does not work regarding training and awareness making of ecological considerations in urban planning practice. Further research should capture the monetary value of ecological considerations, contextualised within a South-African context.	3.3.2
Planning education or further training	General enhancement of ecological literacy among Planners.	Includes ecological aspects and concepts in the planning education curricula as a source of knowledge and comprehensive skill development on planning for people, planning for nature and planning for people in nature, the relations and dependence of humans and the environment. This further includes continuous efforts on challenging planners to rethink urban planning and how to take ecological consideration into account. Concepts such as transdisciplinary collaboration, GI planning, ESSs, and multi-functionality should from the common language of future planners. Linked with the “Planning education or further training” recommendations in Table 9-2, Table 9-3, and Table 9-4.	2.3 3.3 Table 6-23 4.6.1 7.4.2.4

Source: Own construction (2020).

9.7 Concluding the dissertation's recommendations.

Chapter 9 provided the planning profession with recommendation towards the consideration of ecological approaches as part of mainstream urban planning. Based on these detailed recommendations the following broad recommendations are made to the planning profession as a point of departure to integrate ecological approaches in urban planning practice:

- A science-practice foundation is important and could be achieved through transdisciplinary collaboration and transdisciplinary decision-making.
- Involve researchers and practitioners from different disciplines, especially the urban ecological discipline, to collaborate in transdisciplinary research and integrated thinking approaches.
- Different shareholders, for instance local officials and authorities, and non-governmental stakeholders (e.g., public, and private landowners, voluntary organisations, and individuals and communities are to be included towards an ecological approach in urban planning practice.
- The notion of a transdisciplinary team should be further explored within an urban planning context regarding required team members, activities, contributions, and responsibilities towards an ecological approach.
- Both non-monetary and monetary values of ecological considerations should be captured to prioritise ecological approaches.
- Local context (South African) considerations are to be kept in mind and planning practice should build on and expand on existing approaches by linking ecological considerations to land-use, zoning or other requirements and guidelines within the South African context.
- The inclusion of the multi-functionality principle is a crucial strategy to encourage and guide an ecological approach in urban planning practice and should be developed further for South African context-based implementation.
- Higher planning education curricula should prepare future planners with the potential to interpret ecological considerations and to align it with planning related approaches.
- Current planners are lacking ecological knowledge. The development of short courses and training programmes should be hosted for practicing planners as part of their continuous professional development (CPD).
- An appropriate case should be built on education methodologies to equip planners with skills to facilitate ecological considerations and knowledge in urban planning practice.

Ultimately, this research provided urban planning practice with valuable knowledge-foundations and opportunities for further planning research to build on the benefits of ESs and multi-functionality as ecological approaches towards quality future urban planning strategies.

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ANNEXURE 1: RESEARCH QUESTIONNAIRE

Dear Planner,

The following questionnaire is intended for academic purposes in pursuit of a MSc degree in Urban and Regional Planning at North-West University. Your valuable input as a South African planner will be much appreciated.

Please click on the following link in order to complete the questionnaire:

https://docs.google.com/forms/d/e/1FAIpQLSevnh4-N0uRa79Bn6XrBivDISXnd4VnFgTNQiBngK9fP2qgg/viewform?usp=sf_link

Do take note that the completion of the questionnaire is in no way compulsory and your participation is voluntary. You have the right to withdraw from the questionnaire or revoke consent for the use of your responses at any time. Your anonymity will be safeguarded and the confidentiality of your responses will be maintained.

For more details or questions, please contact the study-leader Prof EJ Cilliers at juanee.cilliers@nwu.ac.za or the researcher B van Zyl at burnezyl@gmail.com.

(This research has been considered by The North West University's Faculty of Natural and Agricultural Sciences (FNAS) ethical committee and the study was approved for research purposes - Ethics number: 01464 - 20 - A9).

Sincerely thank you for your time and willingness to contribute to this research!

Kind regards
Burné van Zyl



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Research questionnaire

The questionnaire probes the general understanding among South African urban planners regarding an ecosystem-based approach and current state of integration and implementation of such an approach and related concepts in South African urban planning practice. In addition, the questionnaire aims to determine the environmental worldview among respondents as South African urban planners.

***Required**

What will be expected of you?

You will be expected to answer all 30-questions (15 main questions and one question with 15 sub-questions) in the questionnaire. The completion of the questionnaire should take no longer than 15 minutes.

Section 1:
Demographic data

This section aims to gather demographic data regarding your sector of occupation, current SACPLAN registration, the year you have obtained your degree, as well as, your years of practical experience.

1. Question 1: Please indicate your sector of employment *

Mark only one oval.

- ☐ Public sector
☐ Private sector

2. Question 2: Which SACPLAN registration applies to you? *

Mark only one oval.

- ☐ Technical planner
☐ Candidate planner
☐ Professional planner

3. Question 3: In which year did you received your undergraduate degree *

Mark only one oval.

- ☐ Before 1990
- ☐ Between 1991 and 2000
- ☐ Between 2001 and 2011
- ☐ After 2011

4. Question 4: Please indicate your years of experience *

Mark only one oval.

- ☐ More than 20 years
- ☐ 16 to 20 years
- ☐ 11 to 15 years
- ☐ 5 to 10 years
- ☐ 4 years or less
- ☐ None

**Section 2: An
ecosystem-
based
approach to
urban
planning**

This section intends to determine the general understanding among planners regarding concepts of an ecosystem-based approach in urban planning, as well as, the state of inclusion of these related concepts in South African urban planning practice.

5. Question 5: How familiar are you with the concept of ECOSYSTEM SERVICES ? *

Mark only one oval.

	1	2	3	4	5	
Very familiar	☐	☐	☐	☐	☐	Never heard of it before

6. Question 6: Please define ecosystem services to the best of your knowledge *

7. Question 7: Please provide examples of ecosystem services *

8. Question 8: How would you rank the importance of planning for ecosystem services? *

Mark only one oval.

	1	2	3	4	5	
Important	☐	☐	☐	☐	☐	Unimportant

9. Question 9: How often do you consider ecosystem services in you planning activities? *

Mark only one oval.

	1	2	3	4	5	
Always	☐	☐	☐	☐	☐	Never

10. Question 10: Which of the following concepts have you previously taken into consideration in your planning activities? *

Mark only one oval per row.

	YES	NO
Urban ecology → to study and include knowledge in urban planning practice on how human and ecological processes could coexist in human-dominated environments.	☐	☐
Green Infrastructure planning → a planning approach that aims to develop networks of green and blue spaces in urban areas, designed and managed to deliver a wide range of ecosystem services and other benefits.	☐	☐

11. Question 11a: IF YES: Why did you take these above-mentioned concepts into consideration?

Tick all that apply.

	Ecosystem services	Urban ecology	Green infrastructure planning
Own knowledge	☐	☐	☐
Client or tender stipulation	☐	☐	☐
A problem that required a creative solution	☐	☐	☐
Result of public participation	☐	☐	☐
The recommendation of a specialist	☐	☐	☐

12. Question 11b: If the above-mentioned concepts were considered for other reasons, please specify

13. Question 12: What challenges have you encountered in applying these concepts (mentioned in Question 10 & 11) in planning practice? *

Tick all that apply.

- ☐ Lack of implementation strategies
- ☐ Financial limitations
- ☐ Lack of knowledge regarding the concepts
- ☐ Lack of case studies regarding the benefits thereof
- ☐ Lack of political will

Other: ☐ _____

14. Question 13: Please indicate which ONE of the following phrases do you consider as the best definition for the concept 'MULTI-FUNCTIONALITY' of spaces

Mark only one oval.

- ☐ To concentrate and combine several land-uses (e.g. residential, commercial and institutional) in order to have more than one activity or socio-economic function within the same urban space
- ☐ The spatial arrangement and concentration of mono-functional urban landscape elements (e.g. agricultural, conservation, and recreational land-uses) within an individual urban landscape.
- ☐ The green infrastructure planning principle that entails the capacity of a space to provide multiple ecosystem services within the same space.

Environmental worldview

The section comprises of one main question (Question 14) with 15 sub-questions to determine the environmental worldview among planners. An environmental worldview is described in the literature as the 'lens or filter' through which an individual sees or believes in the relationship humanity has with the natural environment. The New Ecological Paradigm (NEP) scale is an extensive survey-based scale widely employed to measure respondents' environmental worldview based on a respondents' level of agreement on the 15 following questions

15. Question 14: Please indicate your level of agreement on the following 15-items *

Mark only one oval per row.

	Agree	Mildly agree	Neutral	Mildly disagree	Disagree
Q1: We are approaching the limit of the number of people the earth can support	☐	☐	☐	☐	☐
Q2: Humans have the right to modify the natural environment to suit their needs	☐	☐	☐	☐	☐
Q3: When humans interfere with nature, it often produces disastrous consequences	☐	☐	☐	☐	☐
Q4: Human ingenuity will insure that we do NOT make the earth unlivable	☐	☐	☐	☐	☐
Q5: Humans are severely abusing the environment	☐	☐	☐	☐	☐
Q6: The earth has plenty of natural resources if we just learn how to develop them	☐	☐	☐	☐	☐
Q7: Plants and animals have as much right as humans to exist	☐	☐	☐	☐	☐
Q8: The balance of nature is strong enough to cope with the impacts of modern industrial nations	☐	☐	☐	☐	☐
Q9: Despite our special abilities, humans are still subject to the laws of nature	☐	☐	☐	☐	☐
Q10: The so-called ecological crisis facing humankind has been greatly exaggerated	☐	☐	☐	☐	☐
Q11: The earth is like a spaceship with very limited room and resources	☐	☐	☐	☐	☐
Q12: Humans were meant to rule over the rest of nature	☐	☐	☐	☐	☐

Q13: The balance of nature is
very delicate and easily upset

☐☐☐☐☐

Q14: Humans will eventually
learn enough about how nature
works to be able to control it

☐☐☐☐☐

Q15: If things continue on their
present course, we will soon
experience a major ecological
catastrophe

☐☐☐☐☐

-
16. Question 15: Please provide the email address of a fellow urban planner you
think would be willing to participate in the questionnaire *

ANNEXURE 2: THE RESULTS ON THE FIVE DIMENSIONS OF ENVIRONMENTAL THOUGHT AS PART OF THE NEW ECOLOGICAL PARADIGM (NEP) SCALE

The 15 questions of the NEP-scale (Dunlap & Van Liere, 2008) that were employed in Section 3 of the questionnaire (**Annexure one, question 14**), are grounded on five dimensions of environmental thought, namely: 1) Reality to limiting of growth (questions 14.1, 14.6 and 14.11); 2) Anti- anthropocentrism (questions 14.2, 14.7 and 14.12); 3) Vulnerability of nature's balance (questions 14.3, 14.8 and 14.13); 4) Anti-exceptionalism (questions 14.4, 14.9 and 14.14); and **5**) Possibility of an eco-crisis (questions 14.5, 14.10 and 14.15) (Dunlap & Van Liere, 2008). The results of the 15-items were utilised to calculate the average percentages for the five dimensions. Annexure two thus provides the results of the five dimensions. These results served as additional results to determine the overall environmental worldview of South African urban planners.

The reality to limiting of growth dimension

This dimension is concerned with the fact that earth has limited resources and are concerned with the capacity of earth to accommodate the growing numbers of population (Erdoan, 2009:1027; Amburgey & Thoman, 2012:238). When referring to **Table 1-1-**, the limits to growth dimension considers two Pro-NEP questions (Q.1 and Q.11 indicate in dark grey) and one Pro-DSP question (Q.6 indicated in light grey).

Table 1-1: Cumulative % of the reality to limiting of growth dimension.

DIMENTION	NEP SCALE ITEM		CUMULATIVE PERCENTAGE (%)				
			Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
Reality to limiting of growth	1	We are approaching the limit of the number of people the earth can support	42.9	23.8	14.3	9.5	9.5
	6	The earth has plenty of natural resources if we just learn how to develop them	35.7	33.3	7.1	7.1	16.7
	11	The earth is like a spaceship with very limited room and resource	28.6	33.3	31.0	4.8	2.4

Source: Own construction based on questionnaire results (2020).

Based on the results of Table 1-1, Question 1 and Question 11 reflected an ecocentric view among respondents whereas a total of 32% respondents agreed (A + MA) to the two Pro-NEP statements. An anthropogenic view among the respondents was, however, reflected by Question

6, whereas 35 % of the agreed (A + MA) to the Pro-DSP statement, stating that “earth has plenty of natural resources if we just learn how to develop them”.

Hence, overall an average score of 66.5% (after correcting the directionality of the items, that is that Pro-NEP views represents higher numbers) was recorded for the “limiting to growth” dimension, indicating that despite the anthropogenic view results of Question 6, the majority of respondents’ do except the “limited to growth” dimension representing an overall ecocentric worldview among the respondents.

The anti- anthropocentrism dimension

This dimension of the NEP-scale beliefs that nature does not primarily exists for human use and enhances that plants and animals has equal rights of existence as humans (Amburgey & Thoman, 2012:238). The dimension is concern with one Pro-NEP question (Q.7) and two Pro-DSP questions (Q. 2 and Q.12), as indicated in **Table 2-1**.

Table 2-1: The cumulative % of the anti- anthropocentrism dimension.

DIMENTION	NEP SCALE ITEM		CUMULATIVE PERCENTAGE (%)				
			Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
Anti-anthropocentrism	2	Humans have the right to modify the natural environment to suit their needs	9.5	14.3	28.6	14.3	33.3
	7	Plants and animals have as much right as humans to exist	54.8	28.6	9.5	4.8	2.4
	12	Humans were meant to rule over the rest of nature	19.0	23.8	26.2	9.5	21.4

Source: Own construction based on questionnaire results (2020).

Considering the results of Question 2 and Question 12 as indicated in **Table 2-1** , 20% (MD + D) of the respondents’ supported the anti-anthropocentrism statement, whereas 17% (A+MA) opposed the statement. The majority of respondents’ (n=28%) for Question 2 and Question 12 indicated “neutral” to the two questions.

The anti-anthropocentrism statement Question 7, about “plants and animals have equal rights of existence as humans” was supported by 42 % (A+MA) of the respondents’. Overall, the average for the anti-anthropocentrism statement was calculated as 71%, indicating that the respondents overall excepted the anti-anthropocentrism statement and inclining towards an ecocentric worldview.

The vulnerability of nature's balance dimension

The “Vulnerability of nature's balance” dimension considers that human activities have negative consequences and influence the balance of nature (Amburgey & Thoman, 2012:238). Two Pro-NEP questions (Q.3 and Q.13) and one Pro-DSP question (Q.8) are grounded in the “Vulnerability of nature's balance” dimension (see below Table 3-1).

Table 3-1: The cumulative % of the vulnerability of nature's balance dimension.

DIMENTION	NEP SCALE ITEM		CUMULATIVE PERCENTAGE (%)				
			Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
Vulnerability of nature's balance	3	When humans interfere with nature, it often produces disastrous consequences	47.6	33.3	9.5	4.8	4.8
	8	The balance of nature is strong enough to cope with the impacts of modern industrial nations	4.8	7.1	16.7	26.2	45.2
	13	The balance of nature is very delicate and easily upset	42.9	38.1	11.9	4.8	2.4

Source: Own construction based on questionnaire results (2020).

Calculations based on Table 3-1, indicated that 40% of the respondents’ agreed (A+MA) with the negative consequences human activities have on the character of nature, while only 4% of the respondents’ disagreed (MD+D) with the statement (Q.3 and Q.13). The results of the Pro-DSP Question 8, 36% disagreed with the statement that the balance of nature is strong enough to cope with the modern human. Based on these results an overall average for the “vulnerability of nature's balance” dimension was calculated as 81.9%. It could therefore ultimately be seen that based on the “vulnerability of nature's balance” dimension most respondents’ reflects an ecocentric worldview.

The anti-exceptionalism dimension

The anti-exceptionalism dimension refers to the statement that reject the exceptionalism that is based on the worldview that human beings are dominant and higher valued than other organisms in the natural environment (Hawcroft & Milfont, 2010:143; Ntanos et al., 2019:239). The dimension is calculated by considering the one Pro-NEP item (Q.9), indicated in Table 4-1, and two Pro-DSP items (Q.4 and Q.14) also indicated in **Table 4-1**.

Table 4-1: The cumulative % of the anti-exceptionalism dimension.

DIMENTION	NEP SCALE ITEM		CUMULATIVE PERCENTAGE (%)				
			Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
Anti-exceptionalism	4	Human ingenuity will ensure that we do NOT make the earth unliveable	7.1	35.7	31.0	14.3	11.9

DIMENTION	NEP SCALE ITEM		CUMULATIVE PERCENTAGE (%)				
			Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
	9	Despite our special abilities, humans are still subject to the laws of nature	54.8	42.9	2.4	0.0	0.0
	14	Humans will eventually learn enough about how nature works to be able to control it	7.1	14.3	33.3	23.8	21.4

Source: Own construction based on questionnaire results (2020).

Findings on item 4 and 14 of **Table 4-1** indicated that 24.4 % the respondents' disagreed with the two items, while the majority (32%) indicated a "neutral" agreement to the items. Agreement (A+MA) on the two items was only indicated by 17% of the respondents' and therefore still indicates the exception of the anti-exceptionalism statement by the respondents. On the other hand, the Pro-NEP question (item 9) indicated one of the strongest ecocentric worldviews associated with the particular study sample. 49% of the respondents' agreeing on the statement that despite human abilities, they are still subject to and depended on nature. As could be seen in **Table 4-1**, not one (0%) of the respondents indicate a level of disagreement to this particular statement.

Ultimately, the results of the anti-exceptionalism dimension, calculated up to an average of 71.9%, and similar to the previous dimensions, inclining towards an ecocentric worldview among the respondents.

The possibility of an eco-crisis dimension

The point of view of the particular dimension is the recognition that human's dependence and their activities are causing harm to the physical environment (Amburgey & Thoman, 2012:238). The dimension is concern with two Pro-NEP items (Q.5 and Q.10) and one Pro-DSP questions (Q. 10), as indicated in **Table 5-1**. The three items of the dimension specifically reflect on humans' interference to nature and the outcome of a possible eco-crisis if continuing to follow present approaches and processes of human activities.

Table 5-1: The cumulative % of the possibility of an eco-crisis dimension.

DIMENTION	NEP SCALE ITEM		CUMULATIVE PERCENTAGE (%)				
			Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
Possibility of an eco-crisis	5	Humans are severely abusing the environment	54.8	31.0	4.8	7.1	2.4
	10	The so-called ecological crisis facing humankind has been greatly exaggerated	42.9	23.8	14.3	9.5	9.5
	15	If things continue on their present course, we will soon	42.9	23.8	14.3	9.5	9.5

DIMENTION	NEP SCALE ITEM	CUMULATIVE PERCENTAGE (%)				
		Agree (A)	Mildly Agree (MA)	Neutral (N)	Mildly Disagree (MD)	Disagree (D)
	experience a major ecological catastrophe					

The majority of the respondents' (38%) agreed (A+MA) with the two Pro-NEP items (Q.5 and Q.10) and therefore recognises the potential and consequences of an eco-crisis. It was, however, interesting to see that 33% of the respondents' agreed that the ecological crises are only exaggeration. Despite this finding, the overall calculation for the dimension was indicated as 69%, suggesting the overall exception of the "Possibility of an eco-crisis" statements and reflecting a so-called ecocentric worldview.