# Incorporating Water Sensitive Urban Design (WSUD) with Municipal Spatial Development Frameworks (SDFs)


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# ABSTRACT

Extreme climate events are frequent in many parts of the world. Considering these climate events are accompanied by a growing population, resulting in an increased water demand from local municipalities, alternative water-related development strategies should be considered. Incorporating Water Sensitive Urban Design (WSUD) within municipal Spatial Development Frameworks (SDFs) can enhance the sustainability of urban areas. Water resource management is one of the most significant challenges experienced in the 21st century. South Africa is a semi-arid country with variations in rainfall, temporal and spatial precipitation, resulting in a more complex situation. It is expected that by 2030, there will be a water demand and supply gap of up to 17% due to increased urbanisation, population and economic growth, climate change and unrealistic living standards. The relationship between water and land use is not understood, and spatial planning and land-use documents barely address water-related land-use implications. This study aimed to understand the level of incorporation of WSUD within Municipal SDFs. The study reflects on the urban water challenges experienced on local and international levels. Opportunities are identified as to how municipalities can, and should, give effect to WSUD. This was achieved by evaluating four municipal SDFs using the WSUD principles. To prove that municipal SDFs do not incorporate WSUD to secure water sustainability, Witzenberg Local Municipality, Dawid Kruiper Local Municipality, Mangaung Metropolitan Municipality and Cape Town Metropolitan Municipality were selected as case studies. A review of each case study's SDF revealed that the concept of WSUD is not incorporated fully. An extensive evaluation revealed that sustainable water management and planning can be achieved by incorporating WSUD. The study provides a framework for WSUD with guidelines on water sensitivity and conservation for local authorities. This will ensure that municipalities can secure adequate water resources in the future.

**Keywords:** Water Sensitive Urban Design (WSUD), Spatial Development Framework (SDF), quality, Water Sensitive Planning (WSP), and Water Demand

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| DKLM | Dawid Kruiper Local Municipality |
| DRDLR | Department of Rural Development and Land Reform |
| DWA | Department of Water Affairs |
| ES | Ecosystem Services |
| IDP | Integrated Development Plan |
| IWMI | Integrated Water Management Institute |
| IWRM | Integrated Water Resource Management |
| IWRMP | Integrated Water Resource Management Plan |
| IUWM | Integrated Urban Water Management |
| IUWRM | Integrated Urban Water Resource Management |
| KPA | Key Performance Area |
| KPI | Key Performance Indicator |
| MMM | Mangaung Metropolitan Municipality |
| MSDF | Municipal Spatial Development Framework |
| MTSF | Medium Term Strategic Framework |
| SA | South Africa |
| SDF(s) | Spatial Development Framework(s) |
| SPLUMA | Spatial Planning and Land Use Management Act |
| UN | United Nation |
| WRC | Water Resource Commission |
| WSDP | Water Service Development Plan |
| WSP | Water Sensitive Planning |

| | |
|---|---|
| WSUD | Water Sensitive Urban Design |
| WWTWS | Welbedacht Water Treatment Works |

# KEY DEFINITIONS

Table 1 summaries the terms and words relevant to the study:

**Table 1:Glossary**

| Term / Word | Description |
|---|---|
| **Basic Water Supply** | Adequate infrastructure within 200 meters of a household capable of supplying 25 litres water per day per person (DWAF, 2003 as cited by Carden, 2013: viii). |
| **Ecosystem** | The National Environmental Management Biodiversity Act No 10 of 2004 define an ecosystem as a system of animals, plants and micro-organism interacting with their non-living environment as a functional unit. |
| **IDP** | 5-year plan developed to provide a framework for the land use development needs in the municipality (Dzingai, 2016: x) |
| **Integrated Urban Water Resource Management** | Defined as "*a structured planning process to evaluate concurrently the opportunities to improve the management of water, sewage and drainage services within urban areas in ways which are consistent with broader catchment and river management objectives.*" (Andersen & Iyaduri, 2003:19) |
| **Spatial Development Framework** | A spatial development framework that seeks to guide the overall spatial distribution of land use (CS Consulting, 2013:3), also refer to SPLUMA Act 16 (section 21 of 2013). |
| **Urban areas** | Highly populated formal settlements with high levels of infrastructure and economic activities (Carden, 2013: xi) |

| | |
|---|---|
| **Urban Water Systems** | Defined as *"the technical system itself plus the organisation and technical functions needed to build, operate, and maintain the system's functions: i.e., producing and delivering drinking water, and conducting and treating wastewater and urban run-off. Within the system boundaries are included water resources and receiving waters, the products used in the treatment processes (Chemicals), the products extracted from these processes (energy and nutrients), and the various users and stakeholders."* Palme (2007) (as cited by Carden, 2013:2-3). |
| **WSUD** | Urban Planning in a manner that considers and treats water sensitively (Armitage *et al*., 2014:20). |

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# CHAPTER 1: INTRODUCTION

This chapter introduces the research by describing the problem statement in section 1.1 and justifying the research question in section 1.2. It also introduces the methodology in section 1.3 and explains the structure of the dissertation in section 1.4.

### 1.1 Contextualisation and problem statement

Maser (1997:153) emphasises that no commodity is more important than water in an increasingly resource-stressed world, especially in urban areas. By 2050, close to 90% of African and Asian populations will live in urban areas (UN, 2018). To accommodate the population growth in urban areas, urban development cover in developing countries should expand by 326% (Angel *et al.,* 2011:49). Moreover, dryland surface area transformation has doubled since 1970 in response to increasing demand for food crops (Zhang & Yan, 2014:595). Lambin *et al*. (2001:262) emphasise that the persistent changes in land cover and land use significantly affect earth system functions. The rapid increase in urbanisation, population growth and human consumption leads to numerous environmental challenges, including pollution, a notable increase in disaster risks, ecosystem degradation, and climate change (Culwick & Bobbins, 2015; Dodman *et al.,* 2013:12).

However, amidst the plethora of environmental challenges, Armitage *et al*. (2014: i) emphasise the world's dire need for adequate provision of water. Rapidly growing populations, economic hubs, and urbanisation are critical drivers for the increased water demand (Armitage *et al.*, 2014: i) and are directly linked with water challenges (Huggett *et al*., 2004:256). Gleick (1998:572) emphasises that irresponsible water use coincides with increased water demand. Globally, the predicted increase in water demand is projected to be close to 70% by 2050 (Bradley *et al.,* 2002:60-63). To meet the high-water demand, significant amounts of water are transferred from distant sources to water-stressed areas (Gleick, 1998:571).

Water plays a critical role as an economic and social good, necessitating this water transfer (Flint, 2004:48). Sanchez-Rodriguez (2002) states that the interaction between environmental and socio-economic systems results in dynamic and complex cities. In response to the increasing emphasis on more sustainable water planning, the concept of Water Sensitive Urban Design (WSUD) was developed. WSUD is defined as "Water Sensitive and Urban Planning, ensuring that Urban Planning is undertaken in a manner that considers and treats water sensitively" (Armitage *et al*., 2014:20). This concept incorporates sustainable approaches to readdress the relationship between land-use and urban water systems within urban areas (Hillen & Dolman, 2015:2-3).

Population density, planning, and city layout in South Africa have little consideration for the water sector (Fabrizi, 2011). With South Africa being a water-stressed country (Dormido, 2019), Built (2011:30) emphasises the critical need to integrate water-sensitive planning (WSP) with urban planning to reduce the possibility of water availability catastrophes. This need necessitates the incorporation of WSUD with Municipal Spatial Development Frameworks (SDFs) to create more sustainable cities from a water management perspective. SDFs refer to "*a framework that seeks to guide the overall spatial distribution of current and desirable land uses within a municipality*." (CS Consulting, 2013:3). It is a requirement to prepare SDFs for each local municipality in the country. A partnership approach between spatial planning and the water sector is important to meet the needs and objectives of the community (Binney *et al*., 2010). In the past decade, a fundamental change occurred in the planning context, where the notion of sustainable development plays an ever more critical role in guiding future development thinking. By integrating WSUD with SDFs, urban governance and urban areas could be enhanced through, for example, a decrease in flood risk and cost of drainage systems as well as potentially restoring the natural water cycles within urban areas (Armitage *et al*., 2013: viii; Lawson *et al.,* 2014:11). To determine the extent to which the latter is achieved, Armitage *et al*. (2013: viii) recommend evaluating the current urban planning system in South Africa to determine how it incorporates WSUD thinking with development plans such as SDFs.

## 1.2 Research question

Framing a single well-defined research question helps to focus the research and clarifies the research scope — in this case, dealing with the interface between municipal SDFs and WSUD. Having too many research questions and/or objectives tends to obfuscate the research focus and runs the risk of overpromising what the research can realistically deliver. Given the problem statement, the primary research question is:

"To what extent do municipal SDFs incorporate best practice WSUD thinking?"

Having a single well-defined research question is ideal for dissertation research with a limited time and scope for completion (Robson, 2001; Yin, 2014).

## 1.3 Research method

The researcher will address the question through a qualitative research approach (Creswell, 2014:13) based on a case study analysis of a selected sample of SDFs (Yin, 2014:238), as explained in more detail in Chapter 3. Grant & Booth (2009:95) recommend that a qualitative research approach be supported by a literature review of the existing knowledge as the basis for the research *"… by using systematic review methods of search and critically appraise existing research*." The research uses documentation evaluation as the primary research method. The literature review will inform the documentation evaluation method by providing the basic principles for designing the evaluation criteria.

As the first step to the research, a selected sample of municipal SDFs were identified for evaluation similar to other research on documentation quality evaluation (Sandham & Pretorius, 2008; Sandham et al., 2008). The sample of Municipal SDFs covered different types of municipalities as defined in law. The research also aims to cover different municipal contexts related to the relative importance of water issues. The following criteria were applied to identify the sample of SDFs:

1. Only formally approved SDFs were evaluated.

2. A range of different municipalities was covered, i.e., large urban areas (metros), medium-sized urban areas, and small urban areas.

3. Municipalities located in water-stressed areas.

4. Municipalities struggling with water infrastructure management and maintenance.

The evaluation criteria were developed from the international guideline for WSUD (Wong, 2006:2) by translating international best practice principles into the evaluation criteria. Conformance of the SDF reports to international best practice principles was measured against a qualitative scale as follows:

A = Fully considered; fully incorporated in SDF report

B = Partially considered; partially incorporated in SDF report

C = Minimally considered; minimally incorporated in SDF report

D = Not considered; not incorporated in SDF report.

## 1.4 Structure and outline of the dissertation

A summary of the content and structure of the remainder of the dissertation is as follows:

**Chapter 2** discusses theoretical frameworks for WSUD and municipal SDF, respectively, and integrated planning between WSUD and Spatial Planning. This chapter further explains the characteristics and basic understandings of WSUD and further evaluates South Africa's incorporation of WSUD within the municipal SDFs to understand the complexities of the local context.

**Chapter 3** explains the research methodology and process. The explanation covers data collection approaches, the research design, literature review, empirical analysis, methodological limitations, and ethical considerations.

**Chapter 4** presents the results of the empirical investigation into the integration of WSUD within municipal SDFs. This chapter describes the document review results and how spatial planning and land use management can incorporate WSUD. This chapter applies theory to practice and concludes with key findings on the gaps and opportunities for incorporating WSUD.

**Chapter 5** presents the conclusion with specific reference to the incorporation of WSUD with SDFs in South Africa, in line with the main research question. It also provides a synopsis of the findings of each chapter. This chapter concludes by addressing the primary research question. It identifies and translates the research results into a proposed framework for incorporating WSUD in municipal SDFs with a practical guideline for compiling water-sensitive spatial plans.

# CHAPTER 2: LITERATURE REVIEW

This chapter presents the outcomes of the literature review for the research. Section 2.2 reflects on literature covering water management challenges in urban areas while section 2.3 discusses WSUD more specifically, at an international and a national level. Section 2.4 reflects on the integration of water management with municipal SDFs as an IDP sector plan.

### 2.1 Urban water management and challenges

Urban areas are not fixed physical spaces but behave like living organisms that grow, die and revitalise, depending on the urban system design and functioning. Swilling & Anneck (2012) define urban areas as "*emergent outcomes of complex interactions between overlapping socio-political, cultural, institutional and technical networks that are, in turn, in a constant state of flux as vast socio-metabolic flows of material resources, bodies, energy, cultural practices, and information work their way through urban systems*." Infrastructure is important to urban areas in delivering adequate services and resources to urban populations. (Carden, 2013:2-3). Management and development challenges with regard to water supply systems for a balanced urban water cycle result from urbanisation (Carden, 2013:2-3). Urban water systems are defined as "*the technical system itself plus the organisation and technical functions needed to build, operate and maintain the system's functions: i.e., producing and delivering drinking water, and conducting and treating wastewater and urban runoff. Within the system boundaries are included water reserves and receiving waters, the products used in the treatment processes (chemicals), the products extracted from these processes (energy and nutrients), and the various users and stakeholders*." (Carden, 2013: 2-3) A single urban water system is assumed to be integrated as a whole, while the integration of the various components is lacking or problematic and practically impossible to achieve (Mays, 2009).

According to Loucks and Gladwell (1999:12), the water resources available worldwide are estimated at 1.4 billion $km^3$. DWAF (2004) estimated that in South Africa the water available on land for use is 218 400 $km^3$ and the ground water availability is 8 300 000 $km^3$. Freshwater is the only water resource suited for human consumption (Liphadzi, 2007:16). In 2012, Water.org (2012) estimated 2.4 billion people, a third of the world’s population, lives in water-stressed regions and the lack of safe water supplies in developing countries can be linked to 98% of water-related deaths. In 2007, UNFPA (2007) predicted that by 2030 urban growth will have doubled in cities in developing countries. Developing countries are not equipped to handle rapid urbanisation (UNFPA. 2007). In countries such as Asia and Africa the population growth of urban areas will double by 2030 (UNDESA, 2007). Most countries struggle with an adequate supply of safe water.

Differences experienced in urban water challenges between developing and developed countries are summarised in Table 2 (adapted from Carden, 2013:2-4).

**Table 2: Urban water challenges experienced in developing and developed countries**

| **Urban water challenges** | **Developing countries** | **Developed countries** |
|---|---|---|
| | **Status** | **Status** |
| Wastewater management | Challenges with sanitation, water supply and informal settlements | n/a |
| Adequate water supply | Management issues | Mostly solved |
| Global climate change | Uncertainty = unsolved | Uncertainty = unsolved |
| Pollution of water | High pollution rate | Mostly solved |
| Stormwater and drainage | Non-existing | Solved in terms of quantity but quality is problematic |

Source: Adapted from Carden (2013:2-4)

Existing urban water management drivers are not sustainable and result in pollution, overuse, and over-capitalisation (Shamra & Vairavamoorthy, 2009:211). Replacing and repairing dated infrastructure are costly (Donofrio *et al.,* 2009:179). Cities around the world are replacing dated systems with an integrated approach to water management (Donofrio *et al.,* 2009:179). Water in urban areas is managed by sanitation systems separating used water into waste and greywater (Dankmeyer, 2020:43). Stokman (2019) (cited by Dankmeyer, 2020:43) state that water in urban areas is considered an amenity and can lead to increased flood risks.

A comprehensive assessment of water management in agriculture was conducted in 2007 by the International Water Management Institute (IWMI). Agricultural development, increased food security, health, economic development, and environmental conservation were some of the factors considered by the study. Figure 1 illustrates areas of economic and physical water scarcity worldwide. The IWMI (2007:11) defined three levels of water scarcity namely economic scarcity, physical scarcity and approaching scarcity.

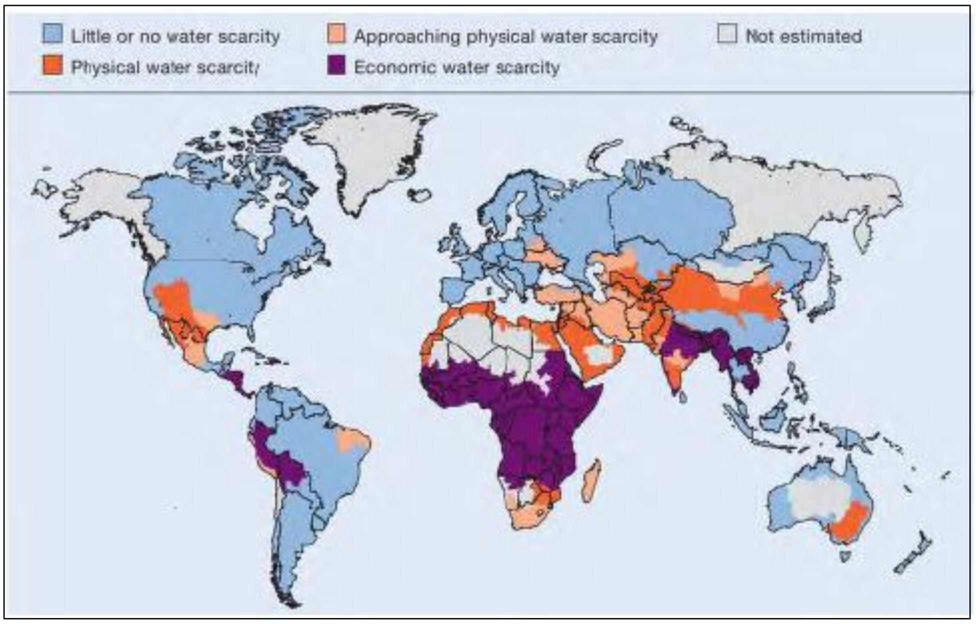


**Figure 1: Worldwide water scarcity**

Source: IWMI (2007:11)

### 2.1.1 Understanding water resources and scarcity in South Africa

According to the NWRS2 (2013:13), South Africa is listed as the 30th driest country globally. Countries such as Botswana and Namibia have more water per person, even though they are much drier than South Africa (NWRS2, 2012:13). Despite being freshwater-scarce, the country has adequate water resources to meet short-to-medium-term requirements (Fisher-Jeffes *et al.,* 2014:1027). According to Carden & Armitage (2012:345), cities in South Africa are under pressure due to the role water play in the economy. They are also under pressure to provide adequate water, and factors such as quality and social divisions are considered. Muller *et al.* (2009) state that the water crises can be averted by managing the existing systems. Increased urbanisation, economic growth, and lack of proper management are significant drivers for increased water demand in urban areas (Fisher-Jeffes *et al.,* 2014:1026). Fisher-Jeffes *et al.* (2014:1026) stated that future economic growth and the management of resource consumption are possible if the current strategies and plans for urban water align. Guide management documents have been released for the water sector. Among these documents are the National Development Plan (NDP), the framework for water sensitive settlements, and the National Water Resource Strategy (NWRS-2) (Fisher-Jeffes *et al*, 2012). The South African Water Research Commission (WRC) developed the Water Sensitive Urban Design (WSUD) as a guide for urban water management within developing countries (Fisher-Jeffes *et al.,* 2014:1026).

Fisher-Jeffes *et al.* (2014:1027) state that the diagnostic report of the National Planning Commission highlights inadequate infrastructure's shortcomings and development challenges. A different development strategy must be implemented, creating opportunities, and reducing poverty (Fisher-Jeffes *et al.,* 2014:1027). Economic growth and water demand are not necessarily linked; SA needs to find innovative ways to reduce resource consumption since unlimited access is not guaranteed to urban areas (Fisher-Jeffes *et al.,* 2014:1027).

Areas throughout South Africa have reached or are quickly approaching the point at which all viable freshwater resources are entirely utilised, with the poor and underdeveloped rural areas experiencing water scarcity. Bingwa (2010) argued that the expansion of informal settlements in the catchment area and the increasein the collapsing of sewerage works puts intense pressure on the river systems of South Africa. This argument is supported by Morgan (2008), who points out that most of the municipal sewerage systems are 50 years old. Increased pressure to meet the water demand is placed on existing infrastructure (Morgan, 2008). Challenges to meet the demand in rural areas are addressed by implementing transfer schemes (Rohr, 2011:39). To ensure the adequate provision of water, governments are building reservoirs, implementing water transfers, and creating several artificial lakes (Nkondo *et al.,*2012 as cited by Rohr, 2011:39).

Since 1994 new legislations and policies have provided progressive water management frameworks (Fisher-Jeffes *et al.,* 2014:1027). The Department of Water Affairs (DWA) acknowledges that traditional water management approaches are insufficient to deal with the growing water demand (DWA, 2013). The Department of Water Affairs (2013) stated that demand management, rainwater harvesting, optimisation of current water resources, protection and reuse should meet the requirements for providing adequate water resources.

Sustaining water services and provision is one of the numerous long-term challenges faced by South Africa's water sector (Carden, 2013:1-2). According to the Department of Water Affairs (as cited by Carden 2013:1-2), service delivery progress has been made. Approximately 2 million people in SA still do not have access to water supply. The urban water cycle in South Africa, uses a distribution network. Muller *et al.,* (2009) found that in many municipalities, a considerable amount of water (40%) is not billed; i.e., non-revenue water. The components of non-revenue water are:

1. Unaccounted water; that is, the water leaving treatment facilities that is not registered due to illegal abstractions, leakages, or vandalism; and
2. Free basic water, which is the provision of an essential service for free (Carden, 2013:2-59).

Consumers may access other sources of water supply such as rainwater, rivers, and springs. The reuse of untreated or treated greywater is a less conventional source of water. Greywater is discharged into separate wastewater and stormwater networks, or the environment (Carden, 2013:2-60). Limited freshwater resources are available and in South Africa these resources are disproportionately available. South Africa is categorised as a water stress country with an average rainfall well below the global average of 860 mm and an estimated freshwater availability of over 100$m^3$ per person (UNEP, 2010). In terms of renewable water resources, SA is categorised as water stressed.

Rainfall is highly variable and seasonal, generally decreasing significantly from the north to the south and from the east to the west of the country. Water use and management in South Africa are determined by natural conditions versus population growth (water need). According to Muller *et al*. (2009), water availability is constrained due to South Africa using 31% of its total actual renewable water resources. In many parts of South Africa, resources have reached or are approaching the point where financially viable resources are fully utilised (Rohr, 2012:38). The World Resources Institute (WRI) (cited by Carden, 2013:2-57) stated that one of the four significant water risk areas worldwide is the Orange-Senqu basin.

Cloete *et al. (*2010) state that SA is heading for a 'water crisis' in terms of quality and quantity. To ensure long-term water security, a reduction of 15 to 30% in water demand is needed to allow for climate change impact. While South Africa faces many challenges due to limited and variable water resources, there is no reason why the country should experience a water crisis provided that existing systems are managed effectively (Muller *et al*., 2009). According to Carden (2013:1-3), concerns about water security in major metropolitan are rising since the metropolitans are economic hubs and resource intensive. Urban water challenges are emerging in South Africa. Water management challenges are experienced in cities due to rapid urbanisation. The growth in urban population will increase economic growth and the many social problems associated with unplanned urban growth. There is a growing gap between water demand (increasing at a rate higher than population) and water supply. Competing demands from different industries result in a decrease in water availability and quality. Solid waste management, land use, wastewater management and drainage issues in urban areas will result in more flood hazards (Jacobsen *et al.,* 2012:2). The quality of freshwater in South Africa is deteriorating due to major sources of water pollution, including acid mine drainage, chemical discharges, uncontrolled sewage disposal, agricultural chemicals, poorly managed wastewater treatment works, runoff from human settlements, and petroleum leaks and spills (IFR, 2009).

Table 3 (adapted from Carden, 2013:2-58) highlights the current challenges that should be addressed.

**Table 3: Current challenges that should be addressed.**

| **Challenge** | **Actions** |
|---|---|
| Impact of climate change | Monitor water resources. |
| Energy sector: high water demand | Alternative water resource, manage the growth in terms of water availability. |
| Demand for transfer and storage schemes: costly | Develop and implement water demand management, explore alternative water resources, and determine different water needs in sectors. |
| Water quality deterioration and poor urban water management | Treat and reuse water. |
| Ecological reserves are not included | Use existing water systems for new developments. |
| Biggest water demand sector: irrigated agriculture | Alternative water supplies such as rainwater harvesting. |

Source: Adapted from Carden (2013:2-58)

In 1999, the South African National State of the Environment Report concluded: "*At present population growth and economic development rates, it is unlikely that the projected use of water resources in South Africa will be sustainable. Water supply will become a major restriction to future economic development … Water resources are already almost fully utilised…. [It is] imperative that South Africa develop both a water-efficient economy together with a social ethic of water conservation and ultimately a culture of sustainability of resource use*."

South Africa is characterised as a semi-arid country with a low rainfall and variations in spatial precipitation distribution (Fourie *et al*., 2020:11). According to the LTAS Report (long-term adaptation scenarios) (as cited by Fourie *et al*., 2020:11), South Africa's water will be impacted by climate change resulting in new water-related challenges, including changing rainfall, water resource availability and extreme weather events.

## 2.2 WSUD

Swatuk (2010) states that "*water is at the heart of all human development*". The differences between developing countries and developed counties are highlighted with respect to water management problems (Carden, 2013:2-3). There are significant differences when it comes to status and response to urban water management issues such as resource degradation, water shortage, urban water pollution, water-related hazards and access to infrastructure and services. In developing countries, the poor management of water impacts the poor people the most (Mays, 2009).

In 2006, the Human Development Report noted that a *"global water crisis"* was emerging (UNDP, 2006). According to the UN (1992), the ability of ecosystems to support environmental constraints determines sustainable development. This holistic approach considers all hydrologic components (Harrison, 2012). Difficulties will be experienced in managing scarce, reliable water resources due to inefficient urban water management systems. WSUD has the potential to manage and reserve water pollution, mitigate the negative effect of water scarcity, increase sustainability and develop resilience within water systems in South Africa (Armitage *et al.,* 2014: ii). It aims to ensure that given prominence within the urban design process by integrating design with other disciplines such as engineering and environmental sciences (Wong & Brown, 2009). WSUD, as defined by Brown *et al.* (2009), is "*an approach to urban planning and design that integrates land and water planning and management into urban design. WSUD is based on the premise that urban development and redevelopment must address the sustainability of water".* Urban designs are governed by the values and aspirations of the community along with the key elements for WSUD (including public participation, useability, aesthetics, flexibility, and function) (Carden, 2013:2-58). Figure 2 illustrates the relationship between water resources and WSUD (adapted from Donofrio *et al.,* 2009: 180).

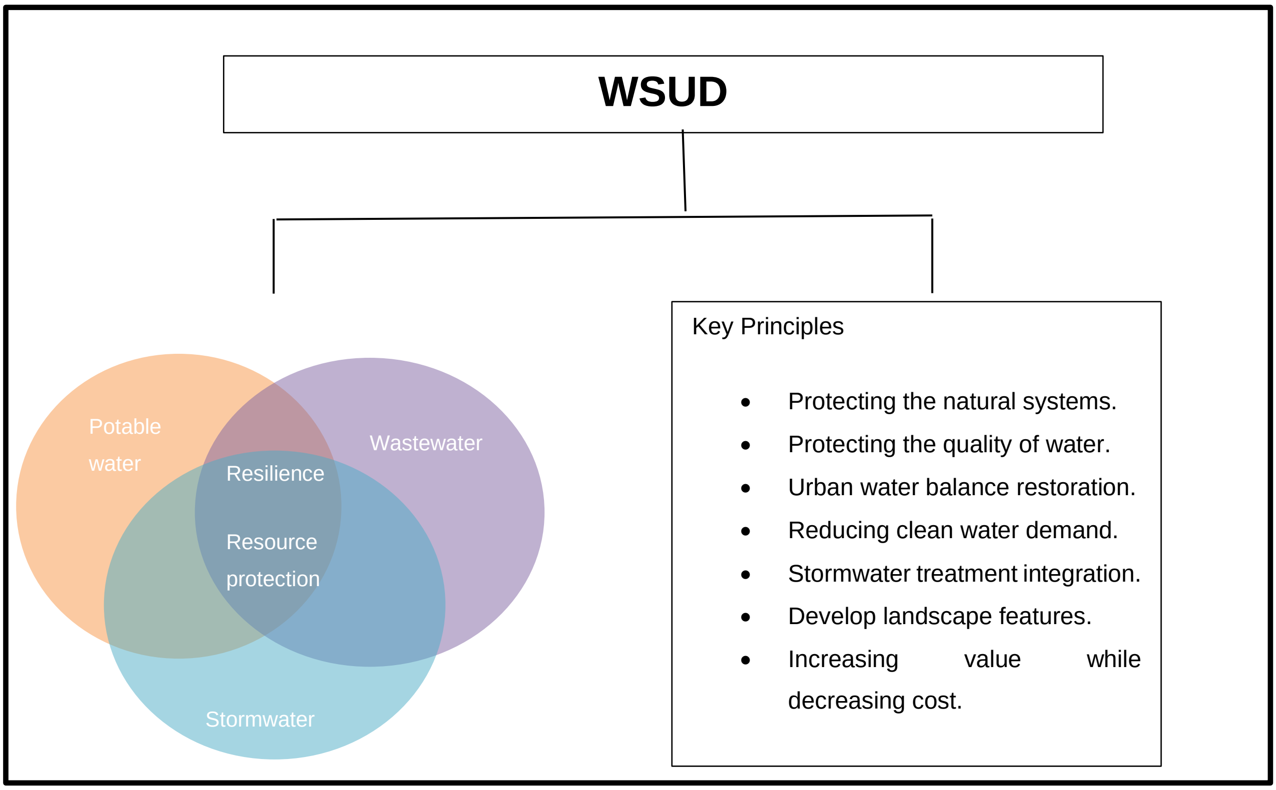


**Figure 2: Relationship between WSUD and water resources.**

Source: Own construction (2021)

WSUD strategies should consider the water cycle as a whole to incorporate the following WSUD principles (see Table 4) (Donofrio *et al.,* 2009:180):

**Table 4: WSUD principles**

| **Key Principle** | **Description** |
|---|---|
| Protecting the natural systems | Enhance and protect the natural watercourses (wetlands, runoff, and rivers) and water cycle within urban areas. |
| Protecting the quality of water. | Improving the quality of urban water (water drainage, rivers, groundwater). |
| Urban water balance restoration. | Maximising reuse of water resources within urban areas by restoring the urban water cycle. |
| Reducing clean water demand. | Reduce water demand by water resource conservation, water demand management and reuse of resources. |

| | |
|---|---|
| Stormwater treatment integration. | Integrate stormwater management and plans into the urban landscape. |
| Develop landscape features. | Integrate water sensitive designs into the landscape. Enhancing urban areas. |
| Increasing value while decreasing cost. | Incorporating WSUD is economically beneficial and must be easily implemented. |

Source: Own construction (2021)

A requirement for sustainable urban planning and development is an integrated approach (Ranhagen *et al.,* 2007).

### 2.2.1 International application of WSUD

Worldwide alternative water management strategies are being implemented (Armitage *et al.,* 2014:6). The most relevant cases of adoption of an integrated WSUD approach are Singapore and Australia. In 2006, the "*Stormwater Industry Association National Award for excellence in Stormwater Management"* was awarded to Liege Street Wetlands in Cannington, Australia. The project reports indicated that the project successfully created new habitats and the location made it perfect for man-made stormwater management. Figure 3 illustrates international WSUD case studies.

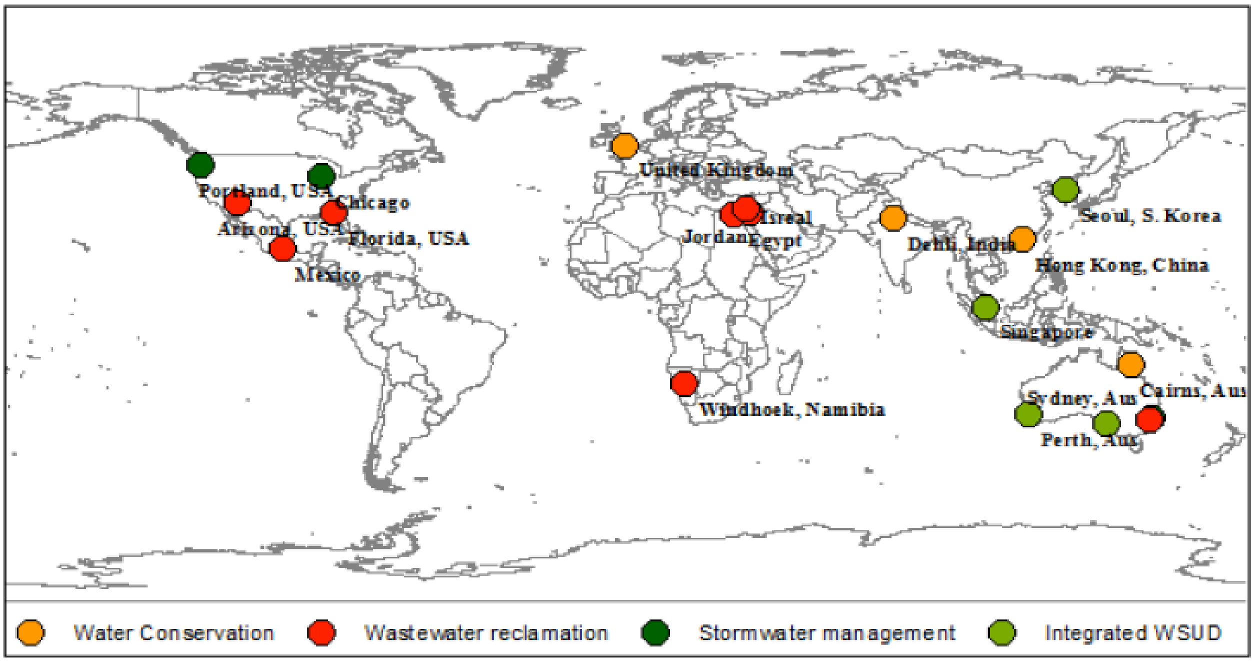


**Figure 3: International WSUD cases**

Source: Armitage *et al.* (2014:7)

According to Armitage *et al.* (2014:7), the worldwide distribution of WSUD indicates a trend of acknowledging water as a scarce resource and better managing it by alternative approaches and improved water management. The incorporation of one to two specific aspects of WSUD is found in numerous cities worldwide. In Australia and Namibia, wastewater is integrated with local water supply and water conservation (Armitage *et al*., 2014:7). There are not many examples of cities integrating all the components of the urban water cycle (sanitation, water supply and drainage); however, one of the main advocates of WSUD is Australia. Several project and integrated water management models have been implemented in Australia and Singapore (Armitage *et al*., 2014:7).

Social, economic, and environmental benefits are experienced through implementing WSUD (Armitage *et al.,* 2014:*7).* Cities that implemented WSUD developed benefits accompanied by resilience (Armitage *et al.,* 2014:7). Some of these benefits are improved urban aesthetics and protecting groundwater (Armitage *et al.,* 2014:7).

Recently, WSUD shifted from stormwater management to integrating urban water. The following case studies will be discussed briefly to show how urban water components can be integrated on different levels as seen in Table 5:

**Table 5: WSUD integration at different levels**

| | |
|---|---|
| **Local scale – Grove Precinct, Australia** | Grove Precinct in Western Perth is a development with features of green technology focusing on renewable, efficient energy. This development uses the integrated water management system consisting of a rainwater system, stormwater and wastewater treatment and re-use (Armitage *et al* 2014: A-1). The Grove Precinct is an example of WSUD at local scale with all the components of the urban water cycle successfully implemented. |
| **Precinct scale – Mawson Lakes** | Mawson Lakes, located in Adelaide, is a small suburban development integrating WSUD that focuses on sustainable stormwater management and wastewater reclamation (Armitage *et al.,* 2014: A-3). Mawson Lake and the Grove Precinct implemented similar WSUD aspects at different scales. |
| **Regional scale – Singapore** | Due to Singapore's political connection to Malaysia and complex water situations, the government developed water-sensitive approaches to managing water resources. The rainfall and population are high, with limited surface area (Armitage *et al.,* 2014: A-7). The Singapore Public Utilities Board states there are few |

| | |
|---|---|
| | natural water resources to utilise, leading to alternative water supply methods. In 1965, Singapore's government realised current water resources (water from Malaysia and reservoirs) would not be adequate for economic and population growth (Armitage *et al.,* 2014: A-7). A multi-faceted political, technical, and intuitional strategy was followed (Armitage *et al.,* 2014: A-7). The government developed an Integrated Water Resource Management (IWRM) plan, which includes four water sources: NEWater, desalinated water, local catchments, and imported water from Malaysia. As a result, improved sustainable water resources are experienced in Singapore, putting Singapore at the forefront of WSUD (Armitage *et al.,* 2014: A-10). |

Source: Own construction (2021)

Wong *et al.* (2020:436) state that technical and social issues of liveability and green cities are influenced by urban water management. Singapore's ABC Waters, China's Sponge Cities and Australia's Water-Sensitive Cities are some of the initiatives considering broader liveability (Wong *et al.,* 2020:436). Figure 4 (Wong *et al.,* 2020:437) describes an urban water transition for historical, current, and future water cycles. Figure 4 represents a culmination of flood and environmental protection, water supply, and long-term resilience and sustainability.

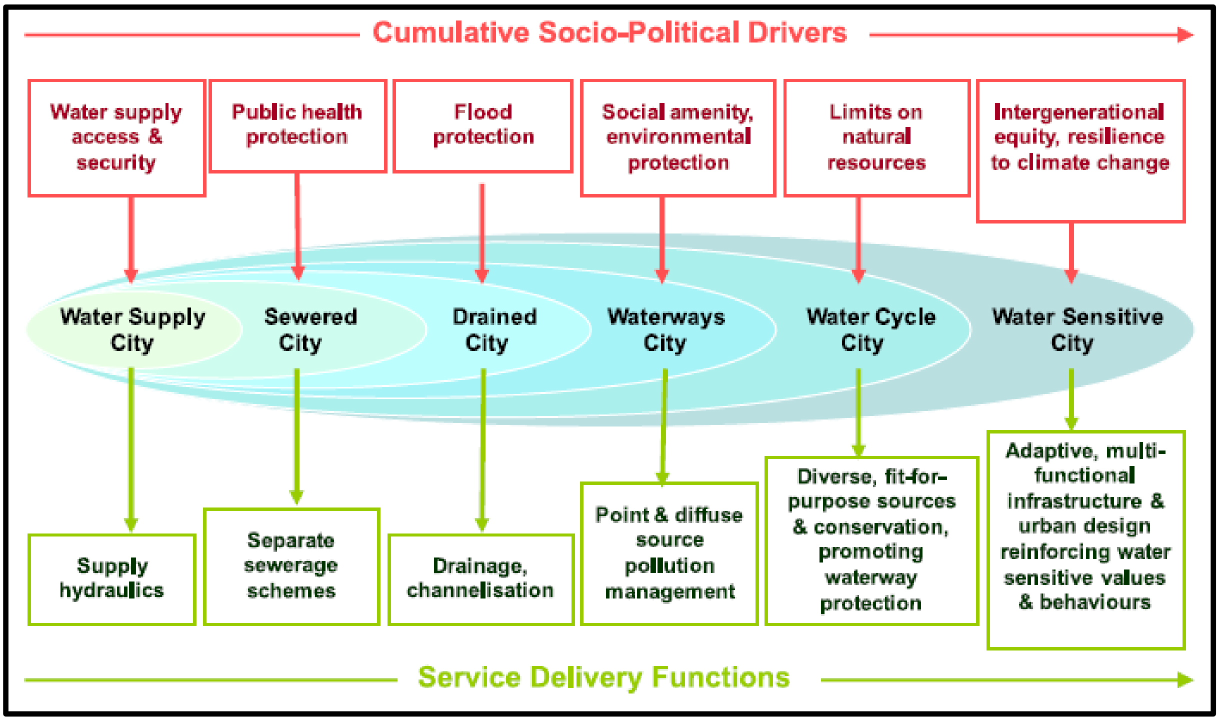


**Figure 4: Towards a Water-Sensitive City**

Source: Wong *et al.* (2020:437)

### 2.2.2 South African application of WSUD

South Africa is urbanising quickly. Urban population is estimated to double over the next 10 years (Jacobsen *et al.,* 2012:2). In 2010, an Urban Water Research Unit was appointed to develop guidelines for WSUD in South Africa. This included a theoretical framework (Fisher-Jeffes *et al.,* 2014:1028). The guideline was developed from Brown *et al.* (2009) with WSUD as a starting point. Although this water sensitive city (WSC) is relevant to South Africa and addresses some of the water sector's challenges, the need to contextualise South Africa's development challenges is there (Fisher-Jeffes *et al.,* 2014:1028). Fisher-Jeffes *et al.* (2014:1028) state that the definition of "*city*" must expand to include a range of settlement types as well as a distinct recognition of how different stakeholders might work collaboratively.

Following initial work on sustainable stormwater management, in 2013, the Water Resource Commission (WRC) published the "*Water-Sensitive Urban Design for South Africa: Framework and Guideline"* (Fourie *et al.,* 2020:16). The publication comprises part one (framework) and part two (guidelines) (Fourie *et al.,* 2020:16). According to the WRC (as cited by Fourie *et al.,* 2020:16), the WSUD framework and guidelines were derived from the "*Water-Sensitive urban design for improving water resource protection/ conservation and re-use in urban landscape"* project. Part one introduces WSUD in SA. This section also defines water-sensitivity in the SA context. Armitage *et al.* (2014) defined water sensitivity as the management of urban water resources within a country through integration of different sectors. WSUD in SA is a relatively new concept. According to Armitage *et al.* (2014: ii), three areas for intervention are highlighted. These include informal, formal and greenfield development areas where there is limited infrastructure with high densities. In the framework, Armitage *et al*. (2014) adopted the term "*water-sensitive settlements*" to include non-urban areas with high density. Part two can be described as an umbrella for a range of activities. The main focus of WSUD is urban water infrastructure and the planning and design thereof and of the surrounding landscape (Fourie *et al*., 2020;18). Detailed information on approaches and illustrations are provided. Part two focuses on (Fourie *et al*., 2020:18):

- Groundwater management – Use of groundwater and artificial recharge
- Stormwater management – Sustainable urban drainage systems approach (in South African context this includes elements such as green roofs, wetlands, retention ponds)
- Sustainable water supply options – Alternative water resources, water demand and conservation management
- Wastewater minimisation – Reuse of treated wastewater

WSUD within the South African context has the potential to increase sustainability by reversing and managing water pollution, minimising the effect of water scarcity and developing resilience (Armitage *et al*., 2014:9). WSUD also has the potential to integrate and transform the divided settlements into water-connected communities (Armitage *et al*., 2014:9). The following issues must be considered when implementing WSUD (Armitage *et al.,* 2014:10):

- Adaptability and uncertainty: It are crucial that the development does not use complex technologies due to a constraint in technical skills and capacity at national and local levels. There is uncertainty about the future in terms of climate change, water demand, demography and politics. These uncertainties result in policy makers being risk opposed.
- Champions: When introducing and embedding WSUD in South Africa, the identification and support of champions are important. A study in 2010 by Taylor found that the progress is rapid where a 'champion' is in a position of authority. Institutional silos preclude initiatives from being followed in larger municipalities, while skills and capacity shortages prevent this at smaller local authorities.
- Ecosystem's goods and services: The economic value of ecosystem services (ES) was used by the SWITCH project to motivate the adoption of WSUD. ES are defined by the benefits to people such as wood, regulating services, food, sense of place, and prevention of soil erosion. While the benefits might be used as motivation in developed countries, the impact in South Africa is unlikely given the inequality and poverty. The transition to WSUD and the benefits should be considered and presented to the different stakeholders in South Africa.
- Equity: Service delivery is already a challenge in South Africa and attempting a water-sensitive and "*green*" approach adds another layer of complexity. Implementing "*green*" projects where no basic services are available will be difficult.
- Health aspects: WSUD in South Africa is a developing notion. This is due to the health risks associated with developing new water pathways that can spread disease.
- Institutional structure: Urban water cycles are managed by different departments with different responsibilities resulting in poor integration and communication of these services. For example, sewage and water supply collection are separated.
- Mitigation: The incorporation of WSUD will help reduce South Africa's environmental impact.

### 2.3 The need for municipal planning: SDF and IDP

Urban water management is an issue of governance and is particularly related to decision making (Carden, 2013:2-62). According to Swatuk (2010), governance systems in South Africa vary greatly and aligning current frameworks for water governance is a challenge due to a complex body of laws and policies. In South Africa, water management falls under the jurisdiction of the Department of Water Affairs and Forestry, which is responsible for the provision of water services at a national level. A predominant framework for water management is provided by the National

Water Act, Act no 36 of 1998. Both the National Water Act, act no 36 of 1998 and the Water Services Act, act no 108 of 1997, aim to develop mechanisms to manage and protect the quality of water resources in South Africa to ensure sustainability.

In accordance with the Water Services Act, water services policies are a requirement for municipalities. These policies are closely aligned with the Integrated Development Plan (IDP) of local authorities. Local government's role in terms of water resource protection and the integration of water services are not spelled out in the IDP.

A high priority for the Department of Water Affairs is water services support to municipalities. According to Grigg (2010) and WWAP and UN-HABITAT (2010), the technological aspects of water supply are not a concern to governance and management, but the social and institutional components are a concern. These include innovative planning, cost recovery and financing; leadership and public participation; a need for a legal framework in respect of risk management; and improving performance and service delivery. According to Binns & Nel (2002:931), integrated development planning in South Africa is steadily growing in its application and success. To guide municipalities, an Integrated Development Plan (IDP) was developed. The IDP is an integrated and holistic strategic plan providing guidance to local governments (Pekelharing, 2008:54). According to Maxim (2008:6), the Spatial Development Framework (SDF) is a key element of the IDP, providing local and provincial municipalities with guidance and development directions. The link between land-use management and integrated development is strengthened by the SDF. This integration could result in sustainable development (Retief, 2007:11).

### 2.3.1 Integrated Development Planning in South Africa

An Integrated Development Plan (IDP) is a municipality's development plan containing short, medium, and long-term strategies and objectives. Integrated Development Planning (IDP) is defined as an interdisciplinary approach, bridging the gap between physical development and economic development (Conyers & Hills, 1984:60). An IDP provides guidance to local government with an integrated, holistic strategic plan by guiding development in the jurisdicted areas (Pekelharing, 2002:54). Since 1996, local governments are legally required to develop an IDP, enforced by the Local Government Transition Act Second Amendment (97 of 1996) (Cilliers, 2010:117). Allocation and management of scarce resources between geographical areas and sectors are managed in a sustainable manner by the IDP and enforced by the Municipal Systems Act of 2000 (Cilliers, 2010:117). Pretorius (2012:10) states that IDP is the preparation of a strategic development plan by the municipality for a five-year period. Although an IDP is legally required, the municipal council must envision an improved quality of life by guiding planning, budget, decisions and management within the municipality (Pretorius, 2012:10). The most important strategic plan used by the South African Government at municipal level is an IDP and this supersedes all other guides and development plans (Achmat, 2002:3).

According to Drewes & Cilliers (2004:16), sustainable development is acknowledged in numerous legal and policy documents. Sustainable development in South Africa adopted an integrated approach. Pekelharing (2008:55) and Retief (2007:11) state that Integrated Development Planning (IDP) aims to align sustainable development with integrated planning throughout all government spheres.

The Department of Provincial and Local Government developed a guide pack with important reasons to implement an IDP (Pretorius, 2012:10):

- To promote intergovernmental coordination;
- To speed up delivery;
- To minimise the effect of apartheid through integration;
- To increase the effective use of scarce resources;
- To strengthen democracy; and
- To attract additional funds.

A plan must be drawn up with the proper management of the planning process before an IDP process can begin. All the involved department structures must be outlined as well as how the process will be monitored (Palmer, 2011:27). Processes to formulate an IDP comprise different phases. The different phases municipalities need to undertake to formulate an IDP are discussed below in Figure 5.

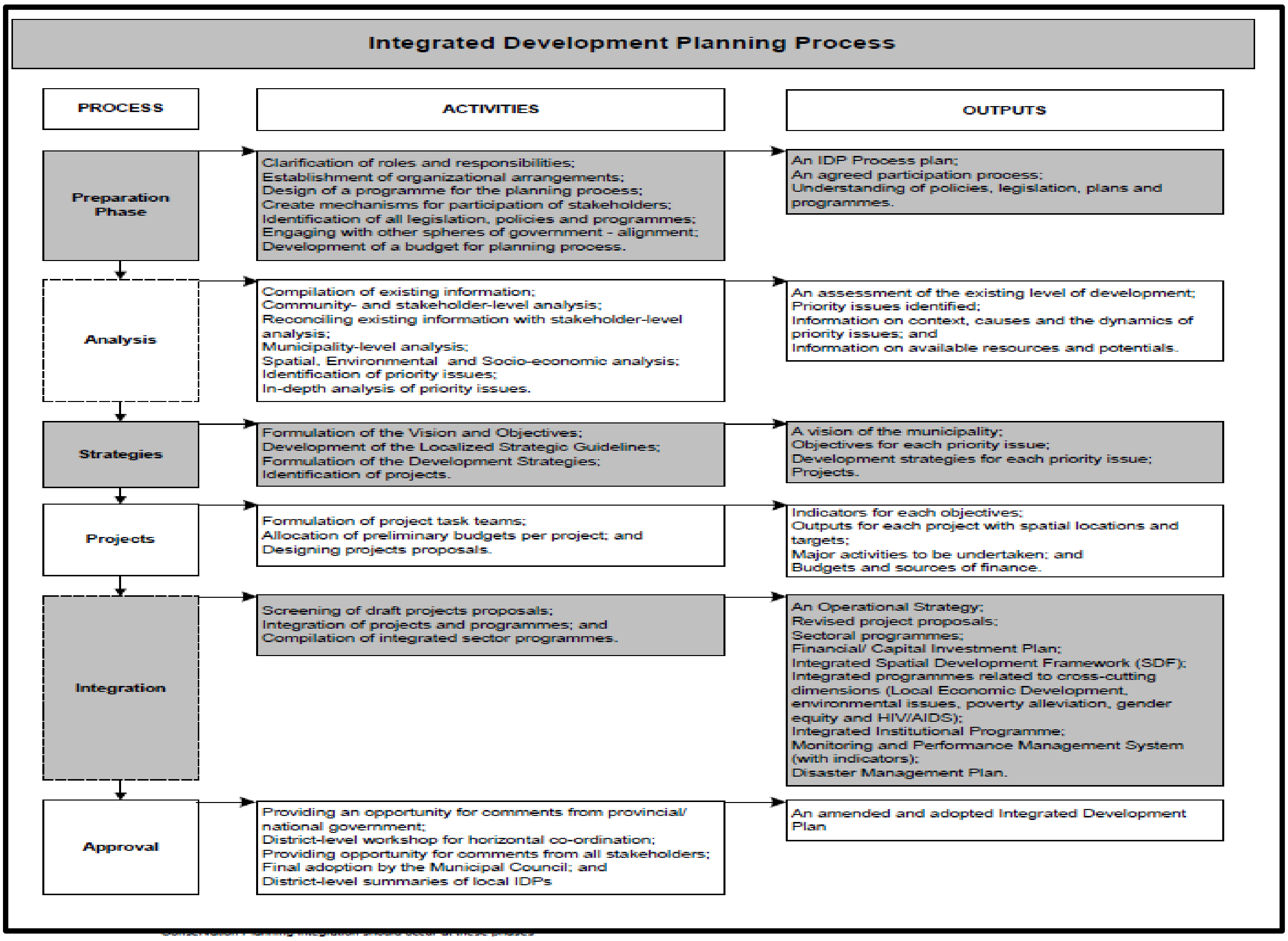


**Figure 5: IDP process**

Source: Palmer (2011:28)

1. **The analysis phase** deals with the current problems and situation in the municipality. This may include a range of problems. To solve the current problems within the municipality, the problems are prioritised. In this phase it is important that stakeholders such as traditional authorities are involved**.**
2. **The strategies phase** formulates development strategies and objectives as well as project visions and identification. Through public participation municipalities understand the problems affecting the people as well as the causes. A priority list with solutions must be developed**.**
3. **In the project phase** projects are identified, and proposals are decided (Municipal Infrastructure Grant, 2004-2007:34). Basic infrastructure projects are listed as important,

and the design of the projects is targeted at people who need it the most. A monitoring plan should be developed and implemented accordingly**.**

4. **The integration phase** ensures that the projects are in line with the municipality's strategies and objectives by using key performance indicators (Mathye, 2002:30). The initiation, implementation and monitoring of projects should be planned by the municipality for a period of five years, as required by law (Musitha, 2012:105).
5. **The approval phase** deals with the completed IDP submitted to the municipal council (Mathye, 2002:31). The completed IDP is presented to the public before final approval. It is the council's responsibility to ensure the identified problems are analysed and solutions are provided as well as compliance with existing legislation (Musitha, 2012:106).

In the IDP process there are numerous role players. The success of the IDP process depends on the identified role players working effectively. Regarding the IDP, the following sets out the responsibilities of the role players at local municipal level (Palmer, 2011:28):

- Integrate different programmes, projects and plans.
- Adopt and prepare the IDP process.
- Councillors are important for decision making during the IDP process.
- Coordinate and manage the planning process.

A critical time period for the IDP is the integration and analysis phase between departments, spheres and sectors.

### 2.3.2 Water Management related IDP sector plans

Environmental and economic problems are constantly faced by communities. According to Flint (2004:50) and Watson (2009:156), development models operate in isolation, with urban planning systems influenced by functioning frameworks. The impact of climate change, urbanisation and industrialisation on urban water management is gaining increasing attention (Carden & Armitage, 2012:345). The implementation of a water management plan is limited by the lack of integration between administrative organs and infrastructure departments (Sletto *et al*., 2019:195). De Groot *et al.* (2010:260) state that landscape-supporting policy tools are restricted, deal with land-use patterns or are sector-oriented. According to Kazmierczak *et al*. (2010:149), land-use management and spatial planning are influenced by high-level policies.

According to Jusi (2013:70), the connection between water and land use is ensured by correct management. Faures and d'Almore (2006) argued that by 2005, Integrated Water Resource Management (IWRM) and water planning should be part of all regional and national development plans. The principles of IWRM are equity in access, efficient water use, implementing planning strategies including all departments and using appropriate technology. Mitchell (2004:1336) highlighted that land-use planning should acknowledge water issues.

The Global Water Partnership (2010) (as cited by Carden, 2013:2-5) defined IWRM as "*a process that promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."* IWRM in terms of urban water management is different in developing and developed countries. In developed countries, the focus is on long-term preservation for future generations, while in developing countries such as SA more immediate issues are addressed in terms of managing water scarcity, poor infrastructure, and high risk of natural events (Carden, 2013:2-5). Mitchell (2004:1335) stated that this holistic approach creates challenges in terms of the standards set by the GWP.

The DWAF (2004) (cited by Carden, 2013:2-6) states that the National Water Act of South Africa (Act 36 of 1998) endorsed IWRM. IWRM is concerned with finding the right balance between the need to maintain environmental integrity and the responsibility of local authorities while fulfilling the constitutional obligation (Carden, 2013:2-5). The success of IWRM is due to the quality of information. Integrator Water Resource Management Plans (IWRMP) aim to assist local authorities in developing water management plans focusing on resource protection and service delivery (Carden, 2013:2-6). Challenges in administrative skills and capacity within local governments burden the implementation of IWRM in South Africa (Haigh *et al., 2010:475-476*).

According to Carden (2013:1-3) Integrated Urban Water Management (IUWM) considers interaction between and the impact of economic, environmental and social components of the urban water cycle. Integrated Urban Water Management is well known in developed countries and municipalities are increasingly considering it in sanitation and water policies throughout South Africa. IUWM forms part of Integrated Urban Water Resource Management (IUWRM) that addresses the impact of urban areas of the natural water cycle while exploring service delivery improvements (Carden, 2013:2-6). Andersen and Iyaduri (2003:19) defined IUWRM as "*a structured planning process to evaluate concurrently the opportunities to improve the management of water, sewage and drainage services within urban areas in ways which are consistent with broader catchment and river management objectives."* The existing water supply and wastewater systems should be abandoned and water issues such as urban runoff and water supply should be integrated by IUWRM. This is required to achieve a balance between political, environmental, economic, and social objectives (Carden, 2013:2-6). IUWM recognises that robust systems are needed for structured decision-making (Carden, 2013:2-7). Mitchell (2006:589-590) argued that an IUWM approach views all urban water services as an integrated physical system while recognising systems within a larger natural landscape as well as an organisational framework. According to Marsalek *et al.* (2008) urban water management should be a scientific understanding as well as planning for the various impacts. Urban water cycle integration and the interaction between them with the impact of human activities are illustrated in figure 6.

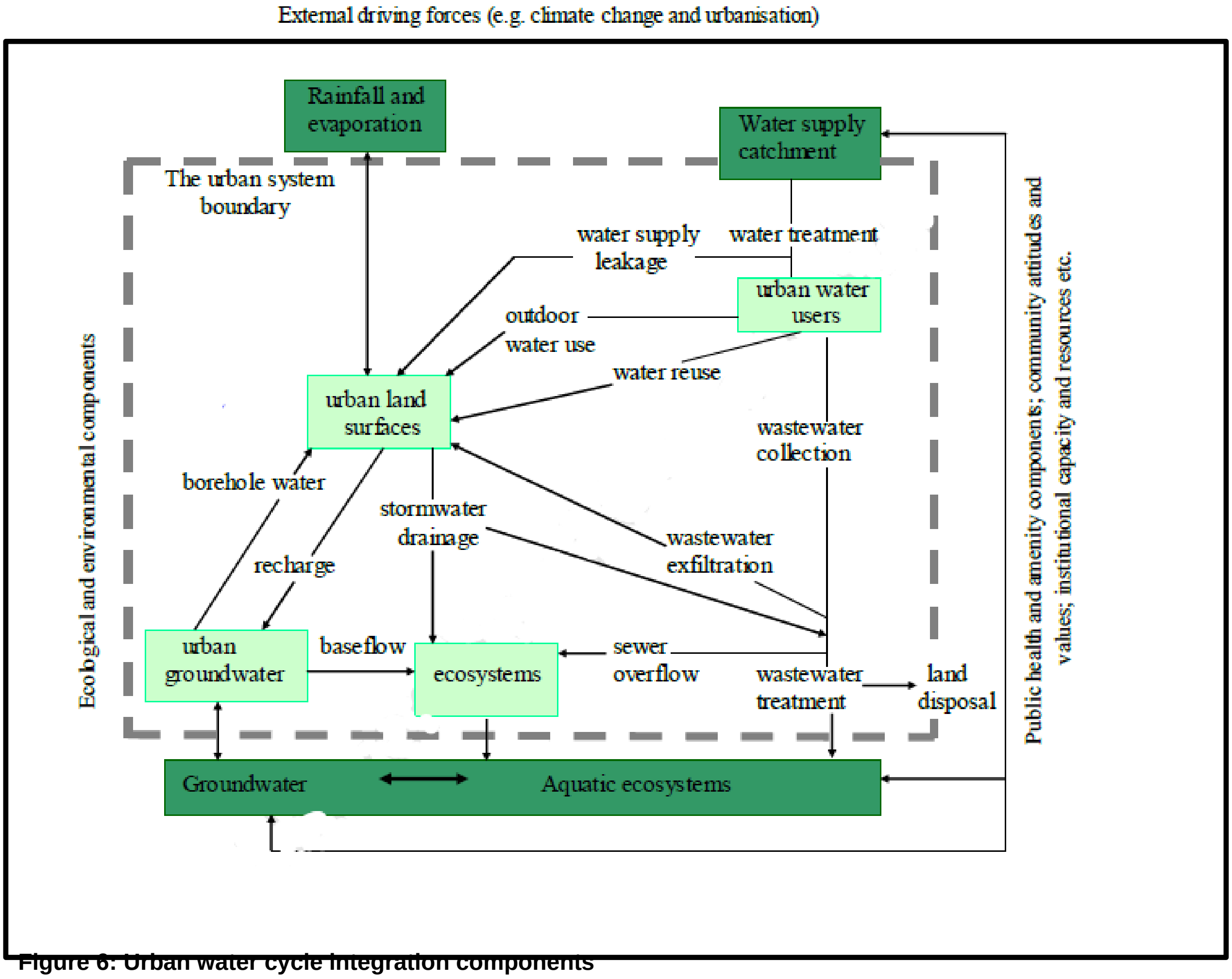


**Figure 6: Urban water cycle integration components**

Source: Carden (2013:2-7)

Various components, such as stormwater that is conveyed away from urban areas, contribute to the lack of integration of urban water cycle. Sustainability of urban water services can be achieved if all the aspects of urban water cycles and services are considered and planned as a whole (Carden, 2013:2-8). Fletcher and Deletić (2008) suggested the following tools should be employed within IUWM:

- Bulk and wastewater treatment
- Wastewater management
- Demand management and water conservation
- Non-structural tools (pricing, education, incentives)
- Utilising non-conventional water resources
- Reducing runoff and runoff storages

IUWM should be implemented at two different levels: 1) considering influence and interaction between socio-political systems; and 2) integration of the systems with the natural environment (Rauch *et al.,* 2005:397).

In South Africa, the lack of integration between local authorities complicates the successful implementation of IUWRM. Burke (2007) (as cited by Carden, 2013:2-6) states that the limited integration of water service provision and water resource management exacerbates water resource management at national and prosocial levels. Political boundaries influence water service provision and sustainable urban water management will not be accepted if there is no link to development or economic development (Armitage *et al*., 2014:22).

### 2.3.3 SDFs as an IDP sector plan

In 2014, SDF guidelines aligning with the Spatial Planning and Land Use Management Act (SPLUMA) were introduced by the National Department of Rural Development and Land Reform (DRDLR) to support the preparation of SDFs. In terms of section 32 of the Municipal Systems Act (Act 32 of 2000), the Integrated Development Plan (IDP) is required to incorporate the Municipal Spatial Development Frameworks (MSDFs) and aims to provide direction and identify key improvement areas to achieve a sustainable and resilient area, with emphasis on local spatial challenges (Laubscher *et al.,* 2016:117; Maxim, 2008). Laubscher *et al.* (2016:117) state that an SDF serves as a guide for the development of land uses in the IDP and is aligned with the stipulations and preconditions of SPLUMA. Section 26 of the Municipal Systems Act (32 of 2000) requires that the SDF forms part of the integration component of an IDP.

"*A municipal Spatial Development Framework (SDF) must contribute to and form part of the municipal integrated development plan, and assist in integrating, coordinating, aligning, and expressing development policies and plans emanating from the various sectors of the spheres of government as they apply within the municipal area."* (SPLUMA, 2013:26).

In South Africa, land use management and spatial planning are guided by a hierarchy of SDFs. Section 6 of SPLUMA (2013:16) states that development norms, principles and standards should be consistent across all spheres of Government. This framework is a long-term strategic planning mechanism showing what and how areas should be developed (Pretorius, 2012:14). According to Maxim (2008) and DRDLR (cited by Pretorius, 2012:14), the main aim of this framework gives effect to the integration of the environment and human settlements while maximising resources, and enhancing the equality, fairness, and effectiveness of the governance. Padarath (2015:36) states that there should be more detail in the MSDF than in regional or provincial SDFs.

An SDF contributes to a municipality's social, economic, environmental, spatial and institutional vision and can be used as to achieve the desired spatial layout. An SDF guides overall current spatial distribution and desirable land uses to achieve the goals, objectives and vision of the municipal IDP. Sustainability and private partnerships are ensured by the framework (Pretorius, 2012:15).

Pretorius (2012:15) states that adequate analyses of the municipality's state and the identification of drivers for change give direction for growth and development of the municipality. The alignment with policies and the implementation plan results in a credible SDF. According to DRDLR (cited by Pretorius, 2012:16), all current and future land-use related decisions must be guided by the SDF. These decisions can include how and where public funds are spent, land-use changes and ideal locations for development.

Guidelines and requirements for the development of SDFs are set out in various policies and legislations such as the Municipal Systems Act (32 of 2000) and Land Use Management Bill (2008) (Pretorius, 2012:14). In 2008, the Department of Rural Development found that many SDFs were not purposeful, credible, or comprehensive, with spatial frameworks being too broad. SDFs did not significantly link to infrastructure planning and land-use management. To ensure credible SDFs, the DRDLR (cited by Pretorius, 2012:16) compiled guidelines for the development of SDFs.

The implementation of the IDP must align between different sectors. This alignment includes time frames, spatial planning, budgets and inter-sector planning processes (Glazewski, 2000:240). According to Pretorius (2012:17), the integration of the SDF and IDP should be aligned to the process cycle. Schoeman (cited by Pretorius, 2012: 17) states that sustainable development is the main interface between frameworks and sectors. Sustainability is the golden thread throughout the integration of the different frameworks. The importance of sustainability and integrated development planning is highlighted by the Development Facilitation Act 108 of 1995. Integrated settlement patterns, and optimal and efficient function are promoted by the principle of integration (Pretorius, 2012:18).

Some norms and principles are shared by SDFs and IDPs:

**Correlating objectives according to Pretorius (2012:18):**

- Use resources sustainably
- Redesign inefficient spatial settlements
- Equitable protection of land rights
- Development potential and areas in need of guaranteed resources
- Identify and create economic development opportunities

**Integrated functionality**

IDPs and SDFs are compelled to integrate. The IDP requires an SDF to be developed while the SDF spatially informs and feeds back into the IDP cycle.

**Public participation**

Social issues and concerns are considered by both the SDF and IDP prior to the spatial analysis. The findings are used to determine the vision and objectives set out for this area by the surrounding community.

**Land Use**

The change and function of the land are regulated by implementing measures for land use (Pretorius, 2012:18). The SDF and IDP regulate land use according to the land development objectives by promoting sustainable and effective land use and preserving natural resources in a sustainable and economic way (Pretorius, 2012:18). To ensure long-term sustainability, the SDF indicates land-uses and development restrictions (Pretorius, 2012:18). Figure 7 indicates the interface between an IDP and an SDF.

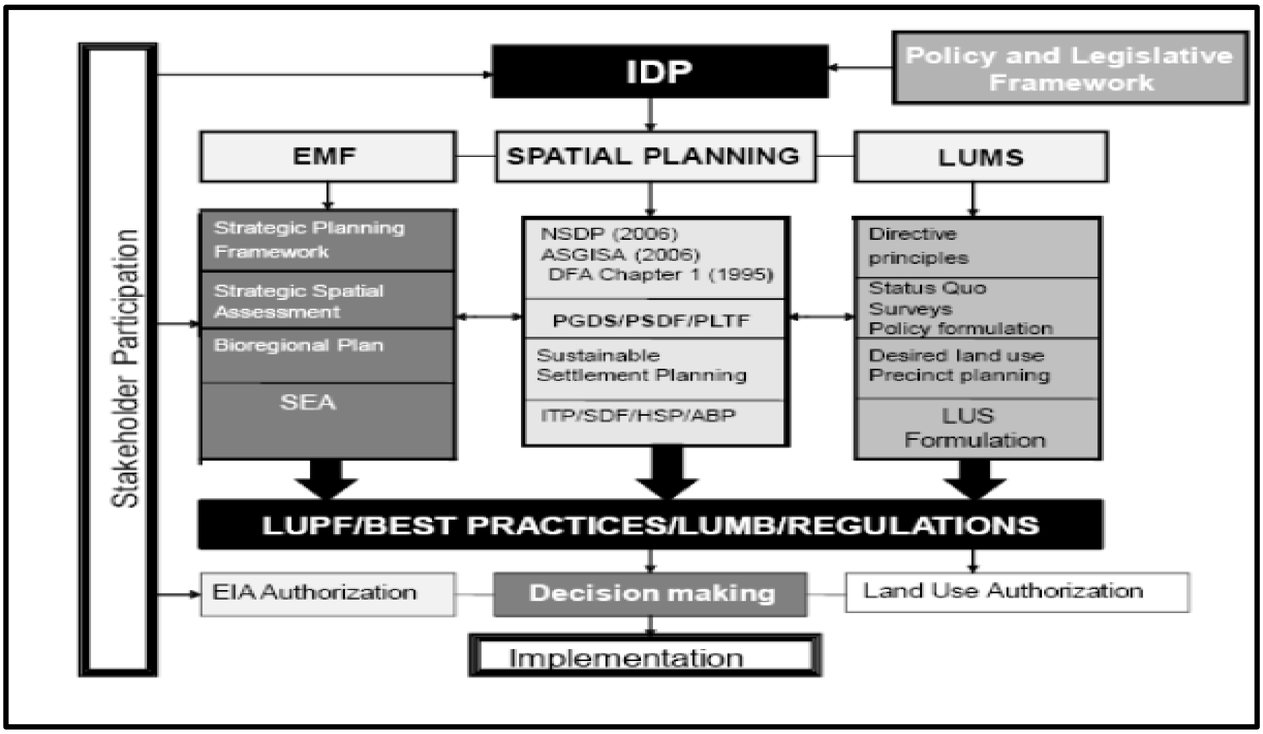


**Figure 7: IDP-SDF interface**

Source: Pretorius (2012:19)

## 2.4 Water-sensitive SDF

A draft National Spatial Development Framework (NSDF) was publicly released in June 2018. According to the NSDF (cited by Rohr, 2019:102), large amounts of water are transferred from stressed catchments to towns and cities to support large populations and the national economy. A gap of 17% between water supply and demand can be expected if the Draft National Water Plan is not implemented (Rohr, 2019:102).

In municipal planning, strategic alignment and direction among all sectors departments and different government spheres are provided by the IDP. Spatial direction and an agenda for sector plans are provided by the MSDF. A SPLUMA-compliant SDF aims to provide a spatial form of the municipality with a 10–to 20-year plan (Rohr, 2019:102). An MSDF is required to describe design strategies and visions addressing economic, physical and social challenges in the municipal area (Rohr, 2019:102). Section 21 of Act 16 of 2013 provides details on how MSDFs can incorporate WSUD by aligning environmental and water resource management and planning (see Table 6 adapted from Rohr, 2019:102-105). The incorporation thereof will be assessed in Chapter 4.

**Table 6: Incorporating WSUD in MSDF**

| **Section 21, Act 16 of 2013** | |
|---|---|
| **An SDF…** | **Planning for water sensitivity** |
| *b) "… must include a written and spatial representation of a five-year spatial development plan for the spatial form of the municipality;"* | Spatial development form is made up of different land- uses that consume and affect water quality. Water quantity and quality must be considered by spatial development form. Wong and Brown (2009) provide guides to achieve settlements with ES. These include the protection of freshwater ecosystems, the promotion of high-density developments and the connection of blue-green corridors. |
| *d) "… must identify current and future significant structuring and restructuring elements of the spatial form, including development corridors, activity spines and economic nodes where public and private investment will be prioritised and facilitated;"* | Area that must be identified when structuring and re-structuring include areas with high groundwater recharge potential, areas of ecological importance such as wetlands, rivers and impoundments, areas affected by |

| | |
|---|---|
| | future structuring and protected areas (Wong & Brown, 2009). |
| *e) "…must include population growth estimates for the next five years;"*<br><br>*f) "…must include estimates of the demand for housing units across different socio-economic categories and the planned location and density of future housing developments;"*<br><br>*h) "…must identify, quantify and provide location requirements of engineering infrastructure and services provision for existing and future development needs for the next five years;"* | It is essential to determine future water demand. SDF growth projection must determine where future growth is likely to take place. Once this is determined, the SDF can set realistic and water-sensitive service levels, set water quantity and quality target areas, develop and implement a growth management plan, and implement a WSUD plan for identified areas of accommodation (Wong & Brown, 2009). |
| *g) "…must include estimates of economic activity and employment trends and locations in the municipal area for the next five years;"* | Target future industrial and business nodes to implement WSUD by developing zones where rainwater harvesting and the reuse of wastewater must be implemented, installing a dual pipeline for the distribution of recycled wastewater and stormwater to use for laundry, flushing a toilet, garden watering and irrigation. |
| *j)" …must identify the designated areas where a national or provincial inclusionary housing policy may be applicable;"*<br><br>*"…must include a strategic assessment of the environmental pressures and opportunities within the municipal area, including the spatial location of environmental sensitivities, high potential agricultural land, and coastal access strips, where applicable;"*<br><br>*k)" …must identify the designation of areas in the municipality where incremental upgrading* | Dictate zones and determine service levels for future housing developments in the municipal area by realistic levels of water-sensitive services, implementing alternative water service technologies and by protecting ecosystems to reduce extensive "man-made" infrastructure. Areas under environmental pressure must be identified (Wong & Brown, 2009).<br><br>These areas include areas of ecological importance and areas where future development might affect the area. Develop |

| | |
|---|---|
| *approaches to development and regulation will be applicable;"* | and implement rehabilitation strategies and implement a guide for future growth management. |
| *l)" …must identify the designation of areas in which:*<br><br>*more detailed local plans must be developed;*<br><br>*shortened land use development procedures may be applicable, and land use schemes may be so amended;"* | Areas where future development will cause water issues must be provided with a WSUD plan. |
| *m) "…must provide the spatial expression of the coordination, alignment, and integration of sectoral policies of all municipal departments;"* | Spatial planning must align with the water department to ensure adequate service delivery. |

Source: Own construction (adapted from Rohr, 2019:102-105)

Water management must be considered within urban design and spatial planning. Water enhances economic development and growth as well as natural ecosystems and human health. According to Rohr (2012), spatial planning provides guides for spatial and water management issues. Water is a resource that enhances urban areas by promoting water sensitivity and sustainability. SA only recently woke up to the fact that we all live in a relatively dry country. All indicators point to a growth in water demand every day. Water and spatial planning are coherent. At municipal level, the two disciplines function independently.

### 2.5 Chapter summary

Armitage *et al.* (2014:2) state that one of the most significant challenges facing South Africa, is the adequate provision of basic services, especially water. Jacobsen *et al. (*2012) (cited by Armitage *et al.,* 2014:2) explain the need for effective management of the existing water systems to address water availability for the future and the impact on the quality. Current water systems are questioned in terms of sustainability due to the pressure on these systems from a range of challenges such as old infrastructure, population growth, capacity constraints and urbanisation.

Over the past 100 years, new models of water capturing, treatment and provision were implemented by large-scale wastewater, centralised water and stormwater systems (Armitage *et al.,* 2014:2). The implemented systems provided efficient collection and disposal of wastewater, safe drinking water and mitigated urban flood risks.

Integrated Urban Water Management and WSUD approaches are implemented as part of the urban water services to address these issues. WSUD systems can be implemented to improve stormwater quality, water conservation, flood control, and promote a healthy environment. The knowledge gap on WSUD systems impedes their mainstream uptake. The systems are still new, and economic, technical, institutional and social aspects need to be covered before implementation. It is the aim of this research to gain a better understanding of the extent to which SDFs have incorporated best practice WSUDs within their SDFs as the basis for sound water management strategies and decision making.

# CHAPTER 3 METHODOLOGY

This chapter presents and discusses the methodology used to answer the research question: To what extent do municipal SDFs incorporate WSUD? Four cases studies were analysed at municipal levels in South Africa as part of the empirical investigation. These four case studies were purposefully selected as samples because they contained applicable information (Weare *et al.,* 2004:129). A comparative analysis of these four cases was conducted through document review. The methodology will be discussed and elaborated on throughout this chapter.

## 3.1 Research design

A research problem is solved by a research design (Leedy & Ormod, 2014:76). Leedy & Ormond (2014:78) defined research design as the procedures followed, including data collection and analyses. This section provides details of the research methodology used to answer the research question formulated in Chapter 1.

### 3.1.1 Case study methodology

Case studies are the preferred method in this research (Yin, 2003:1). Case study research can be defined *"as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used"* (Yin, 1984:23). According to Welman *et al.* (2005:8), qualitative research is done to "*establish the nature of reality and the link between the researcher and the object of the study."* One of the methods used in qualitative research is purposeful sampling, i.e., identifying and selecting information-rich cases (Palinkas *et al.,* 2015:553). Researchers prefer case studies for analytic purposes to support similar cases, phenomena, or situations (Robson, 2002:183).

Case study research has three categories: descriptive, exploratory, and descriptive case studies (Yin, 1984:26). This research uses an exploratory multiple case study approach. The rationale behind the decision is that exploratory research helps determine if a phenomenon exists (Miles *et al.,* 2014:11; Yin, 1984:26). According to Eisenhardt & Graebner (2007:27), the latter is considered more practical since multiple case studies produce a more substantial base for theory-building.

Yin (1984:36) elaborates that an external validity tactic ensures the study's findings are accurately generalised, thus ensuring the quality of the research. Case studies generalise analytical data. However, generalised data is used to examine other data (Yin, 1984:347). Johansson (2003:28) elaborates that generalisation from cases is done analytically based on reasoning is rather than statistical data. A practical example is identifying theoretical problems with WSUD implementation in municipal SDFs.

## 3.2 Research strategies

A qualitative research method was used to evaluate the success of incorporating WSUD within municipal SDFs. Four case studies representing formally approved municipal SDFs at different levels (large urban areas, medium urban areas, and small urban areas) were purposefully selected with water infrastructure management and maintenance and in different geographical locations (water-stressed areas).

The methods used to determine the incorporation of WSUD will be discussed in Section 2.4. Case study analyses are essential for the implementation of WSUD to identify why some municipal SDFs are effective while others are less so.

### 3.2.1 Analysis's methodologies

Reflecting on the research question identified in section 1.2, the researcher chose literature and documentation review as the preferred method. According to Cohen *et al.* (2007:492), this method collects enough data consistently to explain a phenomenon. Blair (2015:17) stated that through literature and documentation review, qualitative and encompassing data is collected.

The primary research aim of this study is to secure future water resources by developing evidence and innovative based WSUD tools. The research, therefore, identified one planning tool, the MSDF and four case study areas, Cape Town Metropolitan Municipality, Mangaung Metropolitan Municipality, Dawid Kruiper Local Municipality and Witzenberg Municipality to be evaluated in terms of their future and existing planning practices on how land use management and spatial planning can give effect to WSUD. For the purpose of this research, the following steps for data analysis were followed:

Step 1: Source SDF reports against the case study selection criteria.

Step 2: Apply die KPIs to the content of the SDF reports.

Step 3: Score the content of the reports against the set criterion.

Step 4: Write up a single case analysis for each individual case study (Section 4,1 to 4.4).

Step 5: Conduct a cross-case analysis by comparing the results across the different case studies (section 4.5).

The reasons for selecting Cape Town Metropolitan Municipality, Mangaung Metropolitan Municipality, Dawid Kruiper Local Municipality and Witzenberg Municipality as case studies are as follow:

- Cape Town Metropolitan Municipality and Mangaung Metropolitan Municipality were selected as case study areas since both these areas represent characteristics of a typical Category A municipality, Making them extremely water wasteful. Growing rural settlements; high levels of household poverty; service backlog and Cape Town Metropolitan being in a water-stress region. Poor service delivery and management or water resources in Mangaung Metropolitan Municipality are the main reason for the selection of this municipality.
- Dawid Kruiper Local Municipality represents characteristics of a typical Category B municipality and is located in a water-stressed region.
- Witzenberg Municipality represents characteristics of a typical Category B municipality with unplanned expansion of rural settlements with a need to utilise water resources.

**Document analyses** of the case studies provided the characteristics of WSUD. More importantly, certain aspects are required for a criterion, which determine the incorporation of WSUD, namely (Donofrio *et al.,* 2009: 180):

- Protecting the natural systems.
- Protecting the water quality.
- Urban water balance restoration.
- Reducing clean water demand.
- Stormwater treatment integration.
- Develop landscape features.
- Increasing value while decreasing cost.

To identify whether WSUD is incorporated, these criteria serve as features to measure the municipal SDFs. There is no clear justification of the WSUD criteria, or the methodologies used. To improve a robust protocol, this research applied a justified method with a selected criterion identifying key performance areas (KPAs) and key performance indicators (KPIs) (Retief, 2007:455). Indicators are preferred instead of a criterion for precision purposes. The building blocks and objectives for understanding and incorporating WSUD are the WSUD principles. It was easy to establish the link between objectives and principles. The objectives and principles were grouped into KPAs with KPIs in question form to determine whether the objectives and principles were reached. As illustrated in Figure 8 (adapted from Retief (2007:455)), the KPIs can be traced back to WSUD principles. This study acknowledges that it is impractical to review SDFs in detail, so the use of indicators ensures a viable holistic review. Indicators add advantage by implying that indicators perform in other related aspects (Retief, 2007:455). The following criteria justified the selection of the indicators (Retief, 2007:456):

- Indicators should be measurable (qualitative and quantitative). These might vary, resulting in performance evaluation features.
- A clear link between WSUD principles, objectives, and indicators.
- Scientifically justified methods: data on the indicators should be readily available.
- Easy understandable indicators with context-specific interpretation.

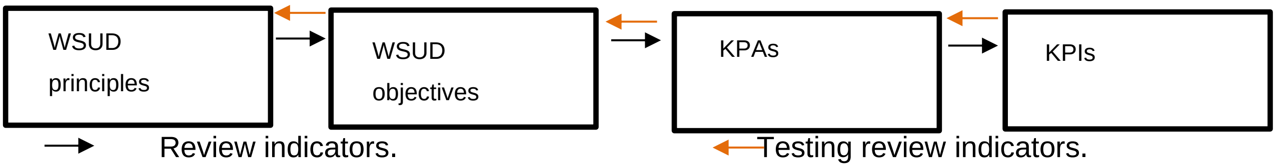


**Figure 8: Design of review indicators**

Source: Adapted from Retief (2007:455).

Based on national and international literature on the topic, 7 KPAs and 14 KPIs were identified to implement WSUD effectively in South African municipalities. Refer to Table 7 for a summary of the KPAs and KPIs.

**Table 7: Summary of the linkage between WSUD principles, objectives, KPAs and KPIs within the South African context**

| **WSUD PRINCIPLES**<br>**Building blocks for WSUD in South Africa** | **WSUD OBJECTIVES**<br>**What needs to be achieved** | **KPAs**<br>**Related to the principles** | **KPIs**<br>**Questions providing an indication if WSUD objectives were achieved** |
|---|---|---|---|
| **Key principles** | **Key objectives** | **KPAs** | **KPIs** |
| Protecting natural systems. These systems include enhancement and protection of natural watercourses and ecosystem processes. | • Integrate the protection of natural systems through WSUD.<br>• To integrate the protection of natural watercourses<br>• To integrate the protection of ecosystem processes | *Natural systems* | KPI 1.1: To what extent were ecosystems integrated?<br>KPI 1.2: To what extent were natural watercourses protected and enhanced?<br>KPI 1.3: To what extent were ecosystem processes protected and enhanced? |
| Protecting the quality of water. Minimise the impact of storm water runoff and improve the quality of water. | • To avoid water pollution that impacts water quality.<br>• To develop appropriate infrastructure to enhance water quality. | *Water quality* | KPI 2.1: To what extent is water quality considered?<br>KPI 2.2: To what extent is appropriate infrastructure considered to enhance water quality? |
| Urban water balance restoration. Minimise the impact on existing water cycles by protecting and rehabilitating natural watercourses. | • To integrate the components of the water cycle in the SDF<br>• To restore the urban water cycle | *Urban water balance* | KPI 3.1: To what extent is the water cycle considered integrated in the SDF?<br>KPI 3.2: To what extent does the SDF consider restoration of the urban water cycle? |
| Reducing clean water demand. Minimise wastewater generation by | • To integrate demand-side water management in SDFs | *Water demand* | KPI 4.1: To what extent does the SDF integrate demand-side water management? |

| | | | |
|---|---|---|---|
| managing minimising portable water demand. | • To integrate alternative approaches to water supply<br>• To manage water demand by informing and involving communities in SDFs | | KPI 4.2: To what extent does the SDF integrate alternative water supply resources? |
| Stormwater treatment. Minimise sediment and erosion from runoff by using the natural water runoff regime. | • To integrate stormwater treatment solutions that minimise sediment and erosion.<br>• To use the natural water runoff regime to manage stormwater | *Stormwater* | KPI 5.1: To what extent were stormwater treatment solutions integrated with the SDF?<br>KPI 5.2: To what extent does the SDF use natural water runoff regime for stormwater management? |
| Develop landscaping features. Integrate water management into urban design and landscaping features to maximise amenities while mitigating the impact of development on the quantity and quality of water. | • To incorporate landscaping features into water management | *Landscaping* | KPI 6.1: To what extent does the SDF make provision for landscaping features to support water management? |
| Increasing the value of ecosystem services while decreasing infrastructure costs. Minimise the impact of development on the recreational, ecological, and aesthetic values by ensuring sustainable development principles are applied with consideration of environmental, economic, and social values in water management. | • To ensure a cost-benefit through the protection of ecosystem services | *Cost benefit* | KPI 7.1: To what extent were ecosystems services priced in the SDF?<br>KPI 7.2: To what extent were the cost benefits of different water management options considered in the SDF? |

Table 8 provides the scoring criteria description. To determine the effectiveness of WSUD implementation, an average score is avoided by using a scoring criterion. A traffic light visualisation is used to make the principle check more understandable

**Table 8: Evaluation criteria**

| Symbol | Explanation |
|---|---|
| A | *Fully incorporated;* fully incorporated in SDF report |
| B | *Partially incorporated;* partially incorporated in SDF report |
| C | *Minimally* incorporated in SDF report |
| D | *Not incorporated;* not incorporated in SDF report |

### 3.3 Description of Case studies

#### 3.3.1 Mangaung Metropolitan Municipal SDF

The Mangaung Metropolitan Municipality is the primary city of the Free State and is centred in South Africa. It is a Category-A municipality and was merged with Naledi Local Municipality in 2016 (Municipalities of South Africa). The Mangaung Metropolitan Municipality covers measures 9886$km^2$ (Municipalities of South Africa). It is reported that water management and supply issues are experienced within the municipality, affecting numerous industries and service delivery to communities (Lekhafola, 2021).

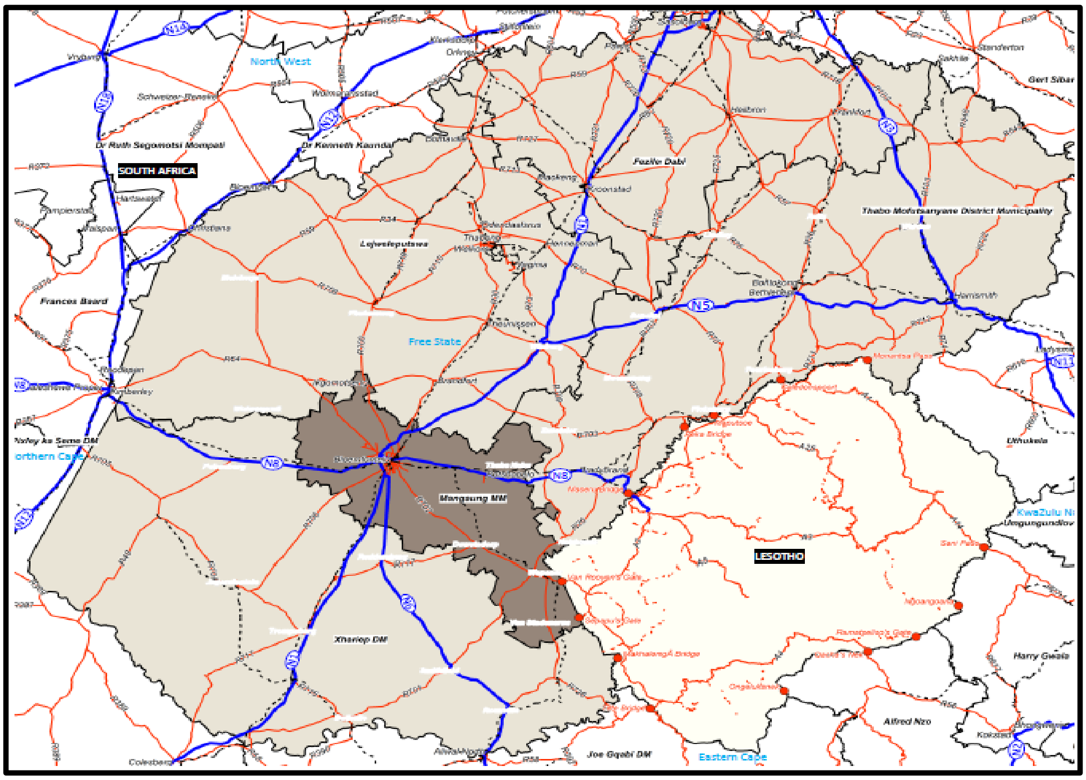


**Figure 9: Mangaung Metropolitan Municipality**

Source: Mangaung Metropolitan Municipality SDF (2020:2)

#### 3.3.2 Dawid Kruiper Local Municipal SDF

The Dawid Kruiper Local Municipality (DKLM) is a Category-B municipality in the Northern Cape Province that forms part of the ZF Mgcawu District Municipality (Macroplan, 2018:4). The DKLM is the largest municipality in South Africa (making up 4% of South Africa), with a geographical area of 44 231$km^2$ (Municipalities of South Africa). The DKLM is one-third the size of the Free State and twice the size of Gauteng (Macroplan, 2018:4). Upington is generally centred in the Northern Cape with natural boundaries such as the Orange River flowing through the town centre, providing a unique, administrative-economic centre (Macroplan, 2018:4). By 2022, the Dawid

Kruiper Local Municipality is projected to have a population of 117,274 people (Macroplan, 2018:6). The Municipality comprises numerous communities and towns, each playing an important role within the functioning of the municipality (Macroplan, 2018:7). The DKLM is situated in a semi-arid district with a 3.8 mm precipitation per year (timeanddate.com, 2021).


**Figure 10: Dawid Kruiper Municipality within the Northern Cape**

Source: Macroplan (2018:4)

### 3.3.3 Cape Town Metropolitan Municipal SDF

Cape Town Metropolitan Municipality is the primary city of the Western Cape. It is a Category-A municipality with a coastline of 294 km (Municipalities of South Africa). It is the second-largest city in South Africa. Cape Town Metropolitan Municipality is the legislative capital of South Africa (Municipalities of South Africa). It is known as 'The *Mother City'* and is a popular tourist destination (Municipalities of South Africa), covering an area of 2446$km^2$ (Municipalities of South Africa). It is hard to believe that Cape Town Metropolitan Municipality was bracing for Day Zero in 2018, resulting from several years of low rainfall that led to a shortage of freshwater reservoirs (Phillip, 2021). Since then, Cape Town Metropolitan Municipality has developed and implemented several water management strategies and encourages water conservation and alternatives.

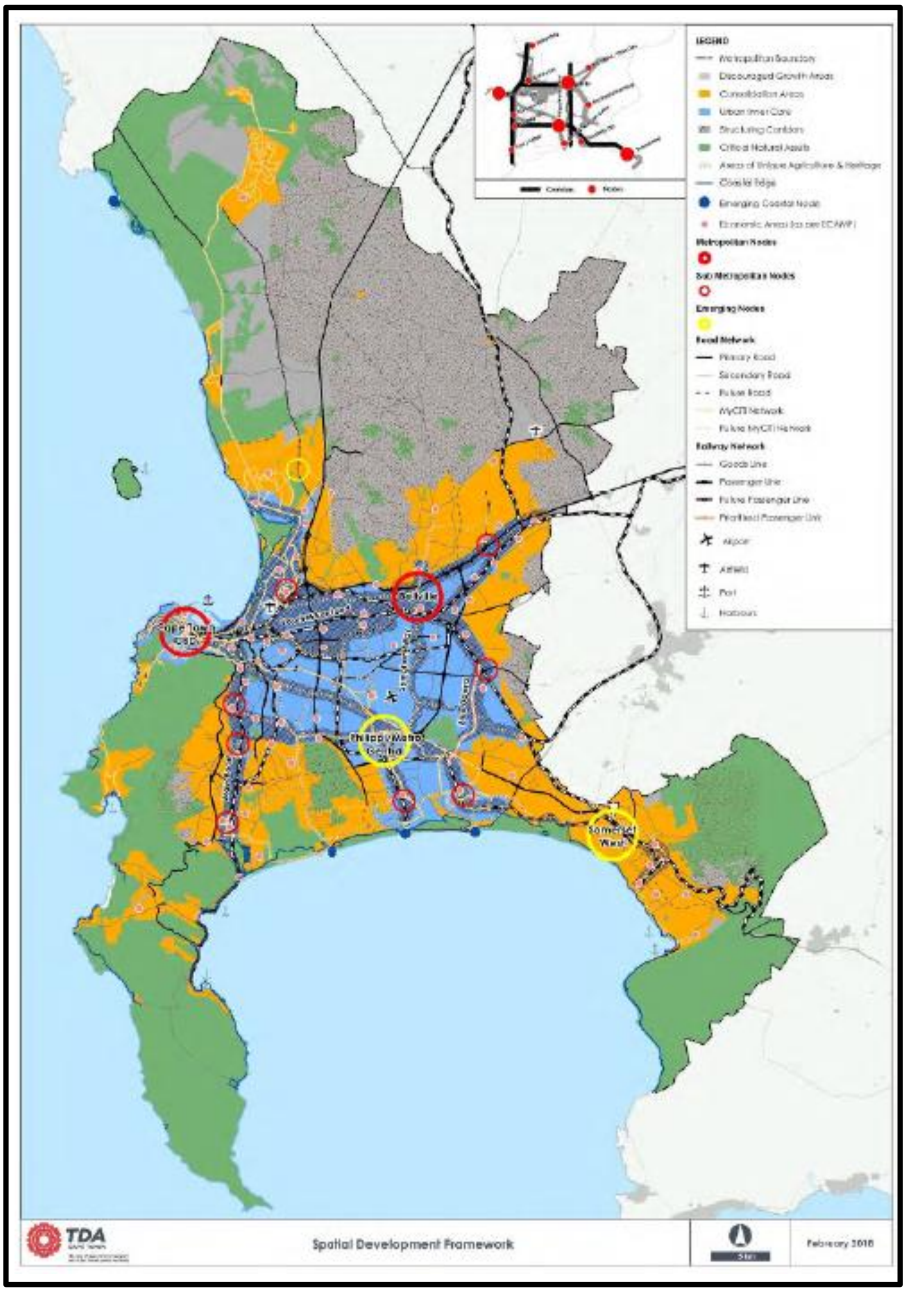


**Figure 11: Cape Town Metropolitan Municipality**

Source: Cape Town Metropolitan Municipal SDF (2017:71)

### 3.3.4 Witzenberg Municipal SDF

Witzenberg Municipality is a Category-B municipality (Witzenberg SDF, 2020:11). It is known for its scientific, economic, cultural, and recreational value (Witzenberg SDF, 2020:11). The Witzenberg Municipality economy is supported by a strong resource base and is subject to increased development. There is a need to utilise the resources to ensure regional and local growth (Witzenberg SDF, 2020:11).

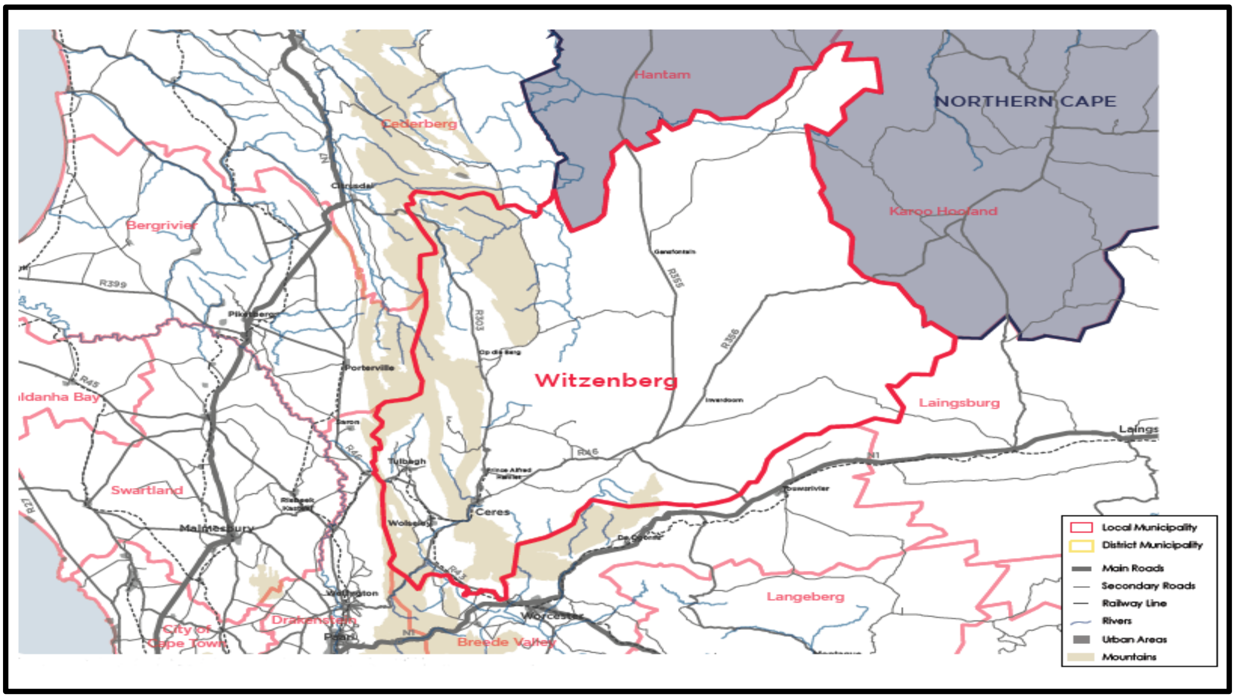


**Figure 12: Witzenberg Municipality within the Western Cape**

Source: Witzenberg Municipal Spatial Development Framework (2020:9)

## 3.4 Data analysis

Relevant literature was combined in a narrative and tabular manner. Using Grant & Booth (2009:95), the findings were categorised into four groups: the known, unknown, uncertainty around the findings and, recommendations for future research.

Collis & Hussey (2014:154) state that challenges might be experienced when corresponding observations with quantitative data regarding the lack clear acceptable set of conventions for analysis. Four key elements that need to be considered when analysing qualitative data are:

- **Comprehending.** Understand the topic before beginning the research.
- **Re-contextualising.** Different contexts can be applied when data is theorised.
- **Synthesising**. Re-organising the findings into different explanations.
- **Theorising.** Qualitative data can be manipulated into different theories to achieve the best results (Collis & Hussey, 2014:155).

The following steps are followed (Leedy & Ormrod, 2014:143-144):

1. Details are organised.
2. Data is categorised for the successful incorporation of WSUD in South Africa.
3. Determine the relevance of other data and reports to this research.

4. Pattern identification: identifying underlying patterns by examining data and interpretations.
5. Generalisations and synthesis: a critical evaluation is concluded.

### 3.5 Ethical considerations

This research was conducted in full compliance with the ethical standards and processes prescribed by the NWU. The research proposal was reviewed by the relevant scientific committee and approved by the Faculty Ethics Committee.

### 3.6 Methodological assumptions and limitations

Due to the extensive nature of the research topic, constraints and limitations are experienced. The research objective is not to discuss whether WSUD is successfully implemented in SDFs. Instead, it emphasises the incorporation of WSUD in SDFs.

In the empirical phase, a purposeful selection of four case studies is made. Other governments in South Africa are not included in this research. The scope of this research focused on the South African context, limited to the incorporation of WSUD in municipal SDFs. This study acknowledges that land-use management and spatial planning function within a hierarchy. Therefore, this study deliberately chose to focus only on municipal-level spatial development frameworks. Although planning recommendations and a conclusion are provided, a comprehensive approach to incorporating WSUD is not provided. As such, this research is limited to:

- Four purposefully selected case studies, namely Witzenberg Municipality, Dawid Kruiper Municipality, Mangaung Metropolitan Municipality, and Cape Town Metropolitan Municipality.
- The SDFs of the municipalities mentioned above.

For future research, there is a need to expand the number of municipal SDFs to link spatial planning and land-use management with WSUD. This study is based on the hypothesis that municipal SDFs incorporate WSUD to ensure sustainable urban development.

### 3.7 Chapter summary

This chapter outlines the research design and methodology used to collect and analyse data to address the research question of this study. It gives detailed information regarding the research design and its general characteristics. Finally, it describes the methods used to collect data and analyse data.

# CHAPTER 4: RESULTS AND DISCUSSION

This chapter presents the results of the research answer the following research question, “To what extent do municipal SDFs incorporate best practice WSUD thinking?”. The results are presented according to the KPIs described in the previous chapter. The result for each KPI will be discussed and elaborated on throughout this chapter. The chapter is structured as sections 4.1 to 4.4 to deal with each individual case whereafter the cross-case analysis is discussed in section 4.

## 4.1 Results related to Witzenberg Municipal SDF

Table 9 summarises the Witzenberg Municipal SDF evaluation based on the relevant KPAs and KPIs. The overall results reveal a particularly poor performance with 13 scores of C to D and a single A to B score. This result suggests a negligible incorporation of WUSD within the municipal SDF. The scores for the KPIs are discussed in sections 4.1.1 to 4.1.7 below in relation to the different KPAs:

**Table 9: Witzenberg Municipal SDF Evaluation**

| **Witzenberg Municipal SDF** | | | **Evaluation justification** |
|---|---|---|---|
| **KPA** | **KPI** | **Evaluation Score** | |
| 1. *Natural systems* | KPI 1.1: To what extent were ecosystems integrated? | C | Refers to natural environment and ecosystems services throughout the SDF with no specific reference to the integration of these systems. |
| | KPI 1.2: To what extent were natural watercourses protected and enhanced? | B | Recognise the importance of natural watercourses as an element of place-making, while protecting and rehabilitating the functionality of these watercourses. |
| | KPI 1.3: To what extent were ecosystem services protected and enhanced? | C | Ecosystem services functionality and natural state must be protected and restored by using alternative, low-impact design concepts. |

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| 2. *Water quality* | KPI 2.1: To what extent is water quality considered? | C | Cape Nature commented on page 103 of the SDF that no urban development with a negative impact on the water quality is permitted. All previously disturbed areas within the municipality should be rehabilitated. |
| | KPI 2.2: To what extent is appropriate infrastructure considered to enhance water quality? | C | The municipality achieved Blue Drop status for the water treatment works over the past three years. The management actions planned are to maintain the quality of drinking water and implement water and sanitation network programmes throughout the municipality.<br><br>All the settlements within the municipality are at risk for water shortage during severe drought due to a shortage of storages dams. Other infrastructure is at risk of collapsing and in need of replacement. New reservoirs are required to supply the adequate amount of water for the recent construction of residential RDP houses. |
| 3. *Urban water balance* | KPI 3.1: To what extent is the water cycle considered integrated in the SDF? | C | Urban development with a negative impact on the water cycle will not be permitted. All development should reinforce existing farm precincts. Spatial form should be designed to embrace the natural ecosystem of the area. The potential contamination of groundwater must be considered as well as the impact on other water cycles. |

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| | KPI 3.2: To what extent does the SDF consider restoration of the urban water cycle? | C | Buffer 1 is large intact portions and natural vegetation not designated as core areas must protect watercourses and encourage low-impact practices for conservation concerns. The management of alien invasive species in river corridors and water catchments should be prioritised. The landfill site in Ceres had been closed since 1999 and rehabilitation is still outstanding. This could lead to underground water pollution. |
| *4. Water demand* | KPI 4.1: To what extent does the SDF integrate demand-side water management? | D | Tierkloof Weir, Koekedouw Dam, Moordenaarskloof and Tierkloof, and Wabooms River Weir supply Tulbagh, Ceres, Wolseley, and Prince Alfred Hamlet. The Water Master plan (approved in 2015) and the Water Service Development Plan (WSDP) (approved in 2019) proactively support water demand programmes and water-wise practices while protecting river corridors, wetlands and catchment areas.<br><br>The SDF aims to develop an agricultural water demand management programme as well as a water demand management programme for industrial and settlement nodes.<br><br>The SDF acknowledges that current infrastructure might not be able to supply adequate future demand. |

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| | | | Tulbagh: Waverenskroon lifestyle estate requires an upgrade of water supply facilities as part of the development. |
| | KPI 4.2: To what extent does the SDF integrate alternative water supply resources? | C | The Sewer Master Plan and WSDP that support the reuse of reclamation wastewater were approved in 2018. Alternative water sources should be considered. With the current use of groundwater, the potential future should be considered and mapped. The response of the SDF for this statement was handed to the PFAs and precinct planning departments. |
| *5. Stormwater* | KPI 5.1: To what extent were stormwater treatment solutions integrated in the SDF? | D | No consideration was given to stormwater treatment solutions in the SDF. |
| | KPI 5.2: To what extent does the SDF use the natural water runoff regime for stormwater management? | C | The Prince Alfred Hamlet Stormwater Management Plan (approved in 2017) supports the replenishment of natural water aquifers/storage for enhanced sustainable urban stormwater management. |
| *6. Landscaping* | KPI 6.1: To what extent does the SDF make provision for landscaping features to support water management? | D | Landscaping features to support water management were not included in the SDF. |

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| *7. Cost benefit* | KPI 7.1: To what extent were ecosystems services priced in the SDF? | D | Natural ecosystems services are not priced in the SDF. The SDF acknowledges the value of ecosystem services to economic development and human well-being. |
| | KPI 7.2: To what extent were the cost benefits of different water management options considered in the SDF? | C | The numerous benefits provided by natural ecosystems are mentioned. No consideration is given to the cost benefits or the cost of implementing manmade infrastructure. |

### 4.1.1 Natural systems: Key findings and conclusion

KPA 1 revealed that only one KPI achieved A to B and two achieved C to D. In the Municipal SDF, natural systems are mentioned and indicated with little to no reference to the integration of these systems. The SDF acknowledges the importance of natural ecosystems, natural watercourses and ecosystem services. Throughout the SDF, protecting and rehabilitating these services are mentioned and it is suggested that low-impact alternative designs accommodating the ecosystem services and natural watercourse should be considered. The biophysical environmental aspect of Witzenberg Municipality identified that the potential land and land capacity have already been matched and it is crucial to find a balance to maintain ecosystems. The SDF's vision enables access to nature without detracting from the integrity and function of natural ecosystems and landscapes.

### 4.1.2 Water quality: Key findings and conclusion

Although the municipality has a Blue Drop status for water treatment, KPA 2 revealed that both KPIs achieved C. This indicates that little consideration was given to the quality of water in the SDF. Although KPA 2 achieved C, the SDF restricted urban development resulting in a negative impact on water quality. The SDF goes even further by stating that all previously disturbed areas within the municipality should be rehabilitated to ensure no further decrease in the water quality. The SDF developed a management action plan to maintain drinking water quality by implementing adequate water and sanitation network programmes. The shortage of storage dams in the municipality and the drought in the area place severe pressure on the current water supply for all settlements in the municipality with all other infrastructure being dated and in need of repair or replacement. The SDF also acknowledges that new reservoirs are required to supply adequate amounts of water for current and future residential urban developments.

### 4.1.3 Urban water balance: Key findings and conclusion

KPA 3 revealed that all the KPIs achieved C. The Witzenberg Municipal SDF will not permit any urban development with a negative impact on the water cycle and aims to design areas that embrace natural ecosystems and services. The SDF has designated core areas aimed at protecting watercourses and encourages low-impact conservation practices. Groundwater contamination must be considered while prioritising water catchments and implementing an alien invasive species management plan. The SDF aims to incorporate the water cycle protection and restoration into spatial development and planning while adopting a reuse water plan.

#### 4.1.4 Water demand: Key findings and conclusion

KPA 4 revealed that all the KPIs achieved C to D. A water demand management programme and agricultural water demand management programme must be developed to ensure adequate water supply to settlements and industrial nodes. Proactive water demand programmes, water-wise alternatives and protection of natural watercourses are encouraged and supported by the Water Service Development Plan that was approved in 2019 alongside the Water Master Plan that was approved in 2015. Prince Alfred Hamlet, Tulbagh, Ceres and Wolseley receive water supplies from Tierkloof Weir, Koekedouw Dam, Moordenaarskloof and Tierkloof, and Wabooms River Weir. It is acknowledged that current infrastructure is not capable of delivering adequate supply with water supply facilities due for an upgrade at the Waverenskroon lifestyle estate in Tulbagh. In 2018, reclamation and reuse of wastewater were approved and supported by the WSDP and Sewer Master Plan. This was to encourage alternative water sources throughout the municipality.

#### 4.1.5 Stormwater: Key findings and conclusion

KPA 5 achieved C to D. Stormwater is mentioned seven times throughout the SDF. Although the Prince Alfred Hamlet Stormwater Management Plan was approved in 2017, the Municipal SDF did not consider or incorporate a stormwater treatment facility. The approved plan supports the replenishment of natural water aquifers/storage for enhanced sustainable urban stormwater management.

#### 4.1.6 Landscaping: Key findings and conclusion

KPA 6 achieved D. While one of the main focuses of the MSDF is to maintain and expand a unique sense of place for people, landscaping and natural features were not considered in the SDF (Witzenberg SDF, 2020:8). The SDF acknowledges the importance of identifying and maintaining unique landscapes while also readdressing the past development imbalances to improve land use, especially in areas characterised by deprivation and widespread poverty. The vision of the SDF is to "(*m)maintain and expand the integrity and continuity of core biodiversity areas, river systems, and other landscape elements to establish connected green networks across the municipal area and region".* To achieve this, the SDF prioritises alien invasive species management plans for river corridors and water catchments, implements proactive management plans for fire and prohibits any activities with a negative impact on critical ecosystems.

#### 4.1.7 Cost benefit: Key findings and conclusion

The KPIs related to KPA 7 achieved C to D scores. Although the SDF acknowledges the economic and human well-being value of ecosystems, natural ecosystems services are not priced. The SDF mentions that there are numerous benefits provided by natural ecosystems without mentioning any specific benefit, or the cost of replacing or implementing the same service through manmade infrastructure. These benefits include fuel, food and water provision services. The SDF aims to incorporate a healthy ecosystem to ensure sustainable economic development and to adapt to climate changes. The SDF aims to maintain and expand current municipal infrastructure that is critical for livelihood, and agricultural and economic development.

## 4.2 Results related to Dawid Kruiper Local Municipal SDF

Table 10 summarise the DKLM SDF evaluation based on the relevant KPAs and KPIs. The overall results reveal a particularly poor performance with 12 scores of C to D and two A to B scores. This result suggests a negligible incorporation of WSUD within the municipal SDF. The scores for the KPIs are discussed in section 4.2.1 to 4.2.7 below, in relation to the different KPAs:

**Table 10: DKLM SDF Evaluation**

| **DKLM SDF** | | | **Evaluation justification** |
|---|---|---|---|
| **KPA** | **KPI** | **Evaluation Score** | |
| *1. Natural systems* | KPI 1.1: To what extent were ecosystems integrated? | C | The importance of natural systems for sustainable development is acknowledged. The natural processes are maintained by the link between ecosystems and the surroundings. |
| | KPI 1.2: To what extent were natural watercourses protected and enhanced? | B | Freshwater ecosystems were considered a priority area to protect alongside rivers and surface water. |
| | KPI 1.3: To what extent were ecosystem services protected and enhanced? | C | The negative impact of alien invasive species on ecosystems is recognised. The SDF's vision is to protect and enhance natural habitats by protecting biodiversity and creating community-supporting ecosystem services. |

| | | | |
|---|---|---|---|
| 2. *Water quality* | KPI 2.1: To what extent is water quality considered? | D | No consideration is given to the quality of water. The SDF wants to improve the quality of life by protecting natural watercourses. |
| | KPI 2.2: To what extent is appropriate infrastructure considered to enhance water quality? | D | No consideration to the quality of water. |
| 3. *Urban water balance* | KPI 3.1: To what extent is the water cycle considered integrated in the SDF? | D | The natural water cycle was not considered in the SDF. |
| | KPI 3.2: To what extent did the SDF consider restoration of the urban water cycle? | B | A Freshwater Ecosystem Priority Area Project was designed to protect the freshwater ecosystem within the DKLM. |
| 4. *Water demand* | KPI 4.1: To what extent does the SDF integrate demand-side water management? | D | The SDF aims to provide adequate services with no specific consideration given to demand-side water management. |
| | KPI 4.2: To what extent does the SDF integrate alternative water supply resources? | D | No alternative water supply resources are considered in the SDF. |
| 5. *Stormwater* | KPI 5.1: To what extent were stormwater treatment solutions integrated in the SDF? | C | Permanent constructed waterways (canals) for irrigation and stormwater trenches with pump stations are integrated in the SDF. |
| | KPI 5.2: To what extent does the SDF use natural water runoff regime for stormwater management? | D | The SDF only makes provision for stormwater runoff to indicate the development impact the runoff water might have. |
| 6. *Landscaping* | KPI 6.1: To what extent does the SDF make provision for landscaping | C | The SDF considers landscaping and urban renewal for creating quality urban environments by prioritising conservation and the |

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| | features to support water management? | | reuse of existing infrastructure, materials and buildings. The inclusion of intensive landscaping in the SDF is to 'beautify' the urban environment with water shortage and the sensitive arid landscape is taken into consideration. Page 49 of the SDF aims to achieve aesthetic integrity by undertaking landscaping that uses natural flora and indigenous vegetation. The SDF does not make provision for landscaping features to support water management. |
| *7. Cost benefit* | KPI 7.1: To what extent were ecosystems services priced in the SDF? | C | The ecosystems services in the DKLM area provide a range of economic and social benefits. The price of these ecosystem services is not incorporated in the SDF. |
| | KPI 7.2: To what extent were the cost benefits of different water management options considered in the SDF? | D | The value of natural ecosystems should be considered to avoid unneeded fiscal pressure on government spheres. |

### 4.2.1 Natural systems: Key findings and conclusion

KPA 1 revealed that one KPI achieved A to B, and two KPIs achieved C to D. The vision of the SDF is to enhance and protect natural habitats by incorporating ecosystem services to create community-supporting service and biodiversity. The SDF indicates freshwater ecosystems areas that must be protected alongside rivers and surface water and acknowledges the importance of sustainable development through natural systems by maintaining the link between ecosystems and the surroundings. The negative impact of alien invasive species on ecosystems and the water supply is recognised and a management plan is developed. The vision of DKLM is built around eight pillars to ensure a self-sustaining ecosystem. Pillars seven and eight aim to conserve natural habitats by incorporating continuous tracts of conservation. The pillars acknowledge the importance of natural resources in sustainable development and aim to provide ecosystem services that the community can benefit from (Macroplan, 2018:3).

### 4.2.2 Water quality: Key findings and conclusion

KPA 2 revealed that all KPIs achieved D. No consideration was given to quality of water for future availability. The SDF aims to protect natural watercourses that will improve the quality of life. DKLM is situated in an arid area and the surrounding developments and agricultural activities decrease water quality. The SDF acknowledges the location of DKLM within a Freshwater Ecosystem Priority Area and aims to maintain the integrity and quality of the Orange River (Macroplan, 2018:21).

### 4.2.3 Urban water balance: Key findings and conclusion

KPA 3 revealed that one KPI achieved B and one achieved D. The SDF neglects the consideration of the urban water cycle and the incorporation thereof in the SDF. Dawid Kruiper Local Municipal SDF only considered freshwater ecosystems and the protection thereof by implementing a Freshwater Ecosystem Priority Area Project. The incorporation, protection and restoration of the water cycle into spatial development and planning encourage the reuse of water.

### 4.2.4 Water demand: Key findings and conclusion

KPA 4 revealed that all KPIs achieved a D. The DKLM SDF does not include a water sector plan addressing the demand and needs for future development and urban growth. Although the SDF aims to provide an adequate supply of water, no demand-side management is implemented. DKLM does not consider any alternative water resources within the municipality. The SDF wants to strengthen partnerships between the private sector and government to improve service delivery.

### 4.2.5 Stormwater: Key findings and conclusion

KPA 5 achieved C to D. The DKLM SDF does not consider stormwater management. Stormwater management is only considered for future development and the impact of the runoff on sensitive ecological areas. The surrounding agricultural sector uses constructed waterways (canals) for irrigation. Stormwater treatment is not considered as an alternative; however, stormwater trenches with pump stations are integrated in the SDF.

### 4.2.6 Landscaping: Key findings and conclusion

KPA 6 achieved C. The DKLM SDF aims to add value to social, visual, ecological and cultural aspects by integrating natural water cycles in urban development. Water quality is protected by the ecological corridors linking natural landscapes with the fragmented urban area. Quality urban environments are created by considering landscaping and urban renewal. This is done by prioritising conservation and the reuse of existing infrastructure, materials and buildings. The SDF aims to 'beatify' the urban environment by acknowledging the landscape and the water shortage of the area; however, no provision is made for water management within the landscape. The SDF encourages urban renewal, prioritising conservation and the reuse of existing infrastructure and buildings.

### 4.2.7 Cost benefit: Key findings and conclusion

KPA 7 achieved C to D. The value of natural ecosystems should be considered to avoid unneeded fiscal pressure on government spheres. With the partnerships mentioned in section 4.2.4, the municipality aims to develop existing and new infrastructure to expand the value of services provided.

### 4.3 Results related to Mangaung Metropolitan Municipal SDF

Table 11 summarises the Mangaung Metropolitan Municipal SDF evaluation based on the relevant KPAs and KPIs. The overall results reveal a poor to average performance with 6 scores of A to B and 8 scores of C to D. These results suggest a negligible incorporation of WSUD in the municipal SDF. The scores for the KPIs are discussed in sections 4.3.1 to 4.3.7 below in relation to the different KPAs:

**Table 11: Mangaung Metropolitan Municipal SDF Evaluation**

| **Mangaung Metropolitan Municipal SDF** | | | **Evaluation justification** |
|---|---|---|---|
| **KPA** | **KPI** | **Evaluation Score** | |
| 1. *Natural systems* | KPI 1.1: To what extent were ecosystems integrated? | B | The critically endangered and highly irreplaceable ecosystems are classified as Spatial Planning Criterion (SPC) A (critical biodiversity area 1). These include terrestrial and aquatic (natural water resources) areas. The SDF acknowledges the importance of these ecosystems and their sustainable function to the area. Development is not permitted, and a management plan has been specifically designed for these areas, focusing on the improvement and maintenance of the natural state of the ecosystem. This ensures that there is no further loss and degrading of the natural ecosystem. |
| | KPI 1.2: To what extent were natural watercourses protected and enhanced? | C | According to the MMM, the transformation action plan is based on the 17 Sustainable Development Goals. Goal 15 aims to |

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| | | | enhance and protect the sustainable use and management of natural ecosystems. This is to reverse biodiversity loss and land degradation. |
| | KPI 1.3: To what extent were ecosystem services protected and enhanced? | B | Outcome 10 of the MTSF (Medium-Term Strategic Framework) aims to protect and enhance ecosystem sustainability and natural resources. The Mangaung Environmental Management Framework of 2017 stated that there are no critically endangered ecosystems within the municipality's jurisdiction. Spatial Planning Criterion D (urban areas transformation) focuses on defining an urban edge to support and manage sustainability within the settlements. |
| *2. Water quality* | KPI 2.1: To what extent is water quality considered? | C | The legal parameters for water quality are exceeded by the Welbedacht Water Treatment Works (WWTWs). Challenges with current and planned upgrading efforts are experienced such as poor water quality management data and lack of environmental performance objectives. MMM (Mangaung Metropolitan Municipality) is a Water Service Provider and Authority and is obliged to provide safe, reliable, and potable water. |
| | KPI 2.2: To what extent is appropriate infrastructure considered to enhance water quality? | C | Rehabilitate degraded aquatic system infrastructures – Water quality is ensured by designated development zones that will aid in preventing chemical and waste dumping into aquatic systems. |
| *3. Urban water balance* | KPI 3.1: To what extent is the water cycle considered integrated in the SDF? | C | Action 5.2 on page 98 encourages the development of a Smart City Concept. In terms of water services, the Mangaung |

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| | | | Metropolitan Municipality focuses on more rigid demand-management initiatives and conservation. This includes the improvement of monitoring and reporting of water management as well as adopting a reuse water plan as standard practice. |
| | KPI 3.2: To what extent does the SDF consider restoration of the urban water cycle? | B | The degraded ecosystems under Spatial Planning Criterion B (ecological support areas 2 and critical biodiversity areas 1 and 2) should be restored and managed to minimise the impact on the function and infrastructure of the ecosystems. The focus is specifically on water and soil ecosystem services. |
| *4. Water demand* | KPI 4.1: To what extent does the SDF integrate demand-side water management? | B | The SDF aims to implement a water demand management system to reduce urban water demand by up to 15%. The SDF aims to implement the Mangaung Gariep Water Augmentation Project for adequate water supply.<br>Groundwater is an important water supply source for rural areas within the municipality. |
| | KPI 4.2: To what extent does the SDF integrate alternative water supply resources? | B | In order for development to occur in the city, water supply sources will have to be secured. Maselspoort Reuse Project aims to optimise water resources through the reuse of water. Rehabilitation of infrastructure is also considered. |
| *5. Stormwater* | KPI 5.1: To what extent were stormwater treatment solutions integrated in the SDF? | C | The Stormwater Master Plan should align with spatial planning and development. One of the challenges identified by the IDP is the massive backlog in service delivery and infrastructure in rural areas and townships. The priority of the SDF is to accelerate |

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| | | | upgrading programmes and develop and implement a comprehensive Stormwater Master Plan. No consideration was given to stormwater treatment solutions. |
| | KPI 5.2: To what extent does the SDF use the natural water runoff regime for stormwater management? | C | On page 90 of the SDF, new infrastructure design for stormwater systems is encouraged. Jammerspruit and Sandspruit should be incorporated as part of the stormwater management system. |
| *6. Landscaping* | KPI 6.1: To what extent does the SDF make provision for landscaping features to support water management? | B | Action 1.2 on page 88 encourages ecological corridor linkages between fragmented and existing natural landscapes. These linkages will enable the survival of animal and plant populations. This ensures continuous protection of biodiversity patterns and adaptiveness to environmental changes.<br>General principles include:<br>• Minimum buffer zone of 150 m for large rivers<br>• 75 m buffer zone for medium rivers<br>• 32 m buffer zone for small rivers<br>• No development within the 1:100 flood line of the surrounding rivers<br>These guidelines ensure protection of water quality. |
| *7. Cost benefit* | KPI 7.1: To what extent were ecosystems services priced in the SDF? | C | The value of ecosystem services was acknowledged, but ecosystem services were not priced in the SDF. |
| | KPI 7.2: To what extent were the cost benefits of different water management options considered in the SDF? | D | The cost benefits of different water management options were not considered in the SDF. |

### 4.3.1 Natural systems: Key findings and conclusion

KPA 1 revealed that two KPIs achieved B, and one KPI achieved C. Outcome 10 in the MSDF aims to sustain natural resources and ecosystems efficiently by enhancing governance capacity and systems to support and develop sustainable human communities. The outcomes aim to create an environmentally sustainable, well-managed and low-carbon economy while effectively mitigating and adapting to climate changes. In the SDF, the Biodiversity Action Plan and its key priorities are acknowledged alongside the Sustainable Development Goals. No critically endangered ecosystems are identified by the Mangaung Environmental Management Framework of 2017. The SDF categorised key spatial planning areas within the municipality. Restoration and protection of ecosystems are mentioned in SPC A, B and C.

### 4.3.2 Water quality: Key findings and conclusion

KPA 2 achieved C. Water quality is mentioned three times throughout the SDF. The poor management of the Wastewater Treatment Works in Mangaung resulted in legal limits being exceeded and a lack of water quality data.

### 4.3.3 Urban water balance: Key findings and conclusion

KPA 3 revealed that one KPI achieved B and the other KPI achieved C. Within the SPC categories, effective resource management and conservation are encouraged. The SDF aims to incorporate the protection and restoration of urban water cycles into spatial planning.

### 4.3.4 Water demand: Key findings and conclusion

KPA 4 achieved B. The majority of the municipality's budget is assigned to engineering services. These services include a Water Demand Management Plan. According to the Mangaung Metropolitan Municipal SDF (2020:153), the budget allocation is sufficient for the shortcomings in service delivery. The Water Demand Management Plan aims to reduce water demand by 15% by 2030.

### 4.3.5 Stormwater: Key findings and conclusion

KPA achieved C. Action 1.3 on page 88 of the SDF aims to implement climate change mitigations and adaption measures. These measures include flood risk management by planning and developing to reduce flood risks and to protect properties and human life. Protection against extreme floods is manageable by sustainable urban drainage systems and natural ecosystems. It is also acknowledged that the Stormwater Master Plan must align with other plans in the municipality.

#### 4.3.6 Landscaping: Key findings and conclusion

KPA 6 achieved B. In the SDF, provision is made for the protection and incorporation of environmental core landscapes. Tourists and recreational areas are encouraged by allocated open spaces throughout the town. The SDF aims to effectively implement natural ecosystems in the urban settings.

#### 4.3.7 Cost benefit: Key finding and conclusion

KPA 7 achieved C to D. Although the SDF allocated a sufficient budget to water management, the cost of replacing natural ecosystems with manmade infrastructure was not included. The SDF prioritised the protection of natural resources and stated that the cost of protecting these resources should be the same as the cost of mining and tourism (Mangaung Metropolitan Municipal SDF, 2020:133).

### 4.4 Results related to Cape Town Metropolitan Municipal SDF

Table 12 summarises the Cape Town Metropolitan Municipal SDF evaluation based on the relevant KPAs and KPIs. The overall results reveal a good performance with 11 scores of A to B and 3 scores of C to D. These results suggest an excellent incorporation of WSUD in the municipal SDF. The scores for the KPIs are discussed in sections 4.4.1 to 4.4.7 below in relation to the different KPAs:

**Table 12: Cape Town Metropolitan Municipal SDF Evaluation**

| **Cape Town Metropolitan Municipal SDF** | | | **Evaluation justification** |
|---|---|---|---|
| **KPA** | **KPI** | **Evaluation Score** | |
| *1. Natural systems* | KPI 1.1: To what extent were ecosystems integrated? | B | The SDF integrates ecosystems with urban development to make the most of the benefits provided by the ecosystems. Functional connectivity and integration are imperative in development to encourage the movement of ecosystems. |
| | KPI 1.2: To what extent were natural watercourses protected and enhanced? | A | The enhancement and protection of the integrity and function of the strips adjacent to aquatic land ecosystems (land adjacent to wetlands, natural watercourses). The environmental strategy focuses on natural system management and planning. This includes all-natural ecosystems and resources. |
| | KPI 1.3: To what extent were ecosystem services protected and enhanced? | A | Integrated management of rivers, wetlands and coastal areas are ensured by the Bioregional Plan. The Bioregional Plan goals include |

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| | | | a cost-effective approach to conservation and management while providing opportunities for tourism, environmental education and recreation in a sustainable manner. |
| 2. *Water quality* | KPI 2.1: To what extent is water quality considered? | B | When considering development rights, the principle of preventing destruction or weakening of water sources should be applied. Integrated water management plans will not only ensure water quality but will enhance social, visual and cultural values within the area. |
| | KPI 2.2: To what extent is appropriate infrastructure considered to enhance water quality? | C | Policy 24.2 developed urban design principles for water-sensitive planning. These include the restoration and protection of surface water and groundwater quality. |
| 3. *Urban water balance* | KPI 3.1: To what extent is the water cycle considered integrated in the SDF? | B | The Environmental Strategy focuses on effective management of natural resources such as water cycles. |
| | KPI 3.2: To what extent does the SDF consider restoration of the urban water cycle? | A | Policy 20.3 on page 122 aims to incorporate the water cycle protection and restoration into spatial planning and development. Policy 24.3 provides guidelines for development with low to no impact on freshwater ecosystems, especially high-productivity ecosystems. |

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| 4. *Water demand* | KPI 4.1: To what extent does the SDF integrate demand-side water management? | B | Demand-side water management within the metropolitan municipality over the last 15 years has remained roughly the same. This is a result of effective demand management measures meeting the long-term supply goal. On page 235 of the SDF, water consumption is estimated to grow by 330 megalitres per day by 2032. A review of consumption in the metropolitan municipality confirmed that households and the economy are becoming resource efficient by using less water. |
| | KPI 4.2: To what extent does the SDF integrate alternative water supply resources? | B | Policy 20 on page 122 encourages an integrated approach to water demand management. Water supply is affected by drought and there is a need to develop alternative resources such as recycling water and other extraction projects. |
| 5. *Stormwater* | KPI 5.1: To what extent were stormwater treatment solutions integrated in the SDF? | B | Concerns about stormwater infrastructure and future developments in the older parts of the metropolitan municipality are acknowledged in the SDF. |
| | KPI 5.2: To what extent does the SDF use the natural water runoff regime for stormwater management? | B | The SDF recognises the importance of ecosystem services for stormwater drainage. The SDF acknowledges that a large proportion of the current stormwater infrastructure throughout the metropolitan municipality is older than 60 years and in need of rehabilitation, replacement and refurbishment. |

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| *6. Landscaping* | KPI 6.1: To what extent does the SDF make provision for landscaping features to support water management? | B | Policy 24 aims to reduce the impact of urban development on natural water cycles by integrating water with the landscape to enhance cultural, social, ecological and visual values. The policy incorporates protection and restoration requirements into spatial development, landscape and planning policies and strategies. Policy 20.3 aims to combine natural water cycles with landscape design strategies and development. |
| *7. Cost benefit* | KPI 7.1: To what extent were ecosystems services priced in the SDF? | C | The SDF acknowledges the benefits provided by ecosystem services, but the value of the services provided by the ecosystems are not priced in the SDF. |
| | KPI 7.2: To what extent were the cost benefits of different water management options considered in the SDF? | B | The Bioregional Plan makes provision for the creation of a cost-effective, integrated approach to ensure that ecosystems within the City remain intact. To upgrade the Bulk Water Augmentation Scheme, the medium-term water infrastructure entails roughly 60% of the costs. |

### 4.4.1 Natural systems: Key findings and conclusion

KPA 1 revealed that two KPIs achieved A and one KPI achieved B. The SDF acknowledges structuring elements that make the metropolitan a destination place. The movement of flora and fauna integration and connectivity is important. The SDF includes strategies to manage or avoid the negative impact of development on natural ecosystems as well as mitigations and rehabilitation of degraded ecosystems. Critical Natural Areas are identified and subdivided into protected areas and conservation areas. The Bioregional Plan ensures that ecosystems continue to deliver a high quality and sustainable service for the community. Policy 23 of the SDF (Cape Town Metropolitan Municipal SDF, 2017:126) aims to increase efforts to enhance and protect natural ecosystems.

### 4.4.2 Water quality: Key findings and conclusion

KPA 2 revealed one KPI achieved B and the other achieved C. Water quality is mentioned once throughout the MSDF. Although only mentioned once, the SDF aims to restore and protect ground and surface water systems. The restoration and incorporation of aquifers are requirements for planning and development. Policy 24 on page 128 of the SDF aims to reduce the negative impact of urban development on ecological support areas (wetlands, rivers and aquifers). This action will ensure water quality.

### 4.4.3 Urban water balance: Key findings and conclusion

KPA 3 revealed one KPI achieved A and the other achieved B. The SDF encourages water recycling and aims to teach and encourage the public and private sectors to use water sustainably. The Environmental Strategy aims to effectively manage natural watercourses in the city. Climate change will put pressure on the urban areas with an extreme impact on water resources. Cape Town Metropolitan SDF encourages the reuse of water and the identification of alternative water sources.

### 4.4.4 Water demand: Key findings and conclusion

KPA 4 achieved B. Policy 20 in the SDF (Cape Town Metropolitan Municipal SDF, 2017:122) aims to enable resource efficiency by integrating and adopting a water demand management plan. Policy 24 promotes the sourcing and use of water supplies by incorporating policing of illegal water extraction. The demand management plan resulted in a decrease in the water demand of the city. This decrease helped the municipality to achieve its long-term water supply goals. The water network capacity throughout the municipality is generally adequate, except for localised areas (Brakkloof, Milnerton and Mountainside) (Cape Town Metropolitan Municipal SDF, 2017:235).

### 4.4.5 Stormwater: Key findings and conclusion

KPA 5 achieved B. The biophysical environment provides ecosystem services such as stormwater drainage. The SDF acknowledges that current stormwater infrastructure is older than 60 years and in desperate need of replacement, rehabilitation and refurbishment. The poor condition of the stormwater infrastructure puts constraints on future developments in the older areas of the municipality. The SDF also recognises the need for a stormwater system adaptable to the changing rainfall patterns to ensure healthy water cycles in the municipality.

### 4.4.6 Landscaping: Key findings and conclusion

KPA 6 achieved B. The natural ecosystems determine the shape and location of developments. Through spatial transformation, the SDF aims to enhance and preserve the natural ecosystems of the city. Spatial strategy 2 (Cape Town Metropolitan Municipal SDF, 2017:57) uses natural open spaces to support spatial justice, creating economic opportunities and quality open spaces. Policy 23.3 on page 126 of the SDF aims to connect biodiversity's by improving, maintaining and protecting linkages. Integrating water with landscapes enhances the social, visual, ecological and cultural values of the municipality. Policy 24.2 on page 128 of the MSDF provides guidelines for the incorporation of WSUD into spatial planning and development.

### 4.4.7 Cost benefit: Key findings and conclusion

KPA 7 revealed one KPI achieved B and the other achieved C. Policy 28.1 on page 131 of the SDF carefully considers the implementation of essential infrastructure and the impact thereof on the landscape. Cost-effective approaches are encouraged by the municipality. Cape Town Metropolitan Municipality aims to address urban growth in the most cost-effective way.

### 4.5 Cross-case analysis

This section explores similarities and patterns in the effective incorporation of WSUD within municipal SDFs across each case study, namely: Witzenberg Municipality, Dawid Kruiper Municipality, Mangaung Metropolitan Municipality and Cape Town Metropolitan Municipality as shown in Table 13.

**Table 13: Results on the effective incorporation of WSUD within municipal SDFs**

| **Evaluation criteria (KPAs and KPIs)** | | **Witzenberg Municipal SDF evaluation scores** | **Dawid Kruiper Municipal SDF evaluation scores** | **Mangaung Metropolitan Municipal SDF evaluation scores** | **Cape Town Metropolitan Municipal SDF evaluation scores** |
|---|---|---|---|---|---|
| **KPA** | **KPI** | | | | |
| *Natural systems* | KPI 1.1: To what extent were natural systems integrated? | C | C | B | B |
| | KPI 1.2: To what extent were natural watercourses protected and enhanced? | B | B | C | A |
| | KPI 1.3: To what extent were ecosystem processes protected and enhanced? | C | C | B | A |
| *Water quality* | KPI 2.1: To what extent is water quality considered? | C | D | C | B |

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|---|---|---|---|---|---|
| | KPI 2.2: To what extent is appropriate infrastructure considered to enhance water quality? | C | D | B | C |
| *Urban water balance* | KPI 3.1: To what extent is the water cycle considered integrated in the SDF? | C | D | C | B |
| | KPI 3.2: To what extent does the SDF consider restoration of the urban water cycle? | C | B | B | A |
| *Water demand* | KPI 4.1: To what extent does the SDF integrate demand-side water management? | D | D | B | B |
| | KPI 4.2: To what extent does the SDF integrate alternative water supply resources? | C | D | B | B |
| *Stormwater* | KPI 5.1: To what extent were stormwater treatment solutions integrated in the SDF? | D | D | C | B |
| | KPI 5.2: To what extent does the SDF use natural | C | D | C | B |

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| | water runoff regime for stormwater management? | | | | |
| *Landscaping* | KPI 6.1: To what extent does the SDF make provision for landscaping features to support water management? | D | C | B | B |
| *Cost benefit* | KPI 7.1: To what extent were ecosystems services priced in the SDF? | D | C | C | C |
| | KPI 7.2: To what extent were the cost benefits of different water management options considered in the SDF? | C | D | D | B |

A consideration of all scores (irrespective of KPI) reveals that out of a total of 56 scores, 35.7% (20 scores) achieved A to B. Moreover, 64.3% (36 scores) achieved C to D, indicating negligible or no incorporation in the municipal SDFs. The scores for the respective KPAs produced the following results:

### 4.5.1 Natural systems: Key findings and conclusion

KPA 1 revealed that out of 12 scores, 58.3% (7 scores) achieved A to B, and 41.7% (5 scores) achieved C to D. In all four cases, the SDF indicates that sensitive environmental areas occur in some measure. Data availability at the time of development helps to identify these areas. The importance of ecosystem services is acknowledged by the SDFs; however, the SDFs do not provide guidelines for the integration of these systems. Natural ecosystems and sustainable development are included in the vision of all four SDFs, but only Cape Town Metropolitan Municipal SDF provides some indication of how to achieve this. Several actions for future consideration include:

- Enhance and protect the integrity and function of ecosystems as part of the Environmental Strategy that focuses on natural system management and planning.
- Integrate management to ensure a cost-effective approach to conservation and management while providing opportunities for tourism, environmental education and recreation in a sustainable manner.
- Integrate ecosystems with urban development to make the most of the benefits provided by the ecosystems.
- Promote building design and construction that are efficient.

### 4.5.2 Water quality: Key findings and conclusion

KPA 2 revealed that out of a total of 8 scores, only 25% (2 scores) achieved A to B and 75% (6 scores) achieved C to D. While all four SDFs quantify the extent of future development, they fall drastically short on considering the implications of that future development for the availability and quality of water. There is no alignment between WSUD and the municipal SDFs. In all four cases, there is no mention of WSUD whatsoever. Surface water from rivers and dams is the main source for economic and domestic purposes. Water resource pollution is a major problem in South Africa as land-use activities impact and contaminate water resources. The quality of water resources is generally not addressed in spatial planning. The overutilisation, pollution and land-use changes led to a decline in water resource availability and quality.

### 4.5.3 Urban water balance: Key findings and conclusion

KPA 3 revealed that out of a total of 8 scores, 50% (4 scores) achieved A to B and 50% (4 scores) achieved C to D. There is a lack of consideration of the urban water cycle and integration in the SDFs. Dawid Kruiper Local Municipal SDF only considered freshwater ecosystems and the protection thereof by implementing a Freshwater Ecosystem Priority Area Project.

Witzenberg Municipal SDF will not permit any urban development with a negative impact on the water cycle and aims to design areas that embrace natural ecosystems and services. The SDF has designated core areas aimed at protecting watercourses. Groundwater contamination must be considered while prioritising water catchments and implementing an alien invasive species plan. The Mangaung Metropolitan Municipal SDF and Cape Town Metropolitan Municipal SDF focus on effective management of natural resources and on more rigid demand-management initiatives and conservation. Both SDFs aim to incorporate water cycle protection and restoration into spatial development and planning while adopting a reuse water plan.

### 4.5.4 Water demand: Key findings and conclusion

KPA 4 revealed that out of a total of 8 scores, 50% (4 scores) achieved A to B and 50% (4 scores) achieved C to D. A mandatory water sector plan of which the main purpose is to address future water needs and demand is not included in the Dawid Kruiper Municipal SDF. The Dawid Kruiper Municipality does not consider demand-side water management; however, does aim to provide adequate water supply sources with no alternative water supply resource. The Witzenberg Municipal SDF, Cape Town Metropolitan Municipal SDF and Mangaung Metropolitan SDF included:

- A demand-side water management plan
- Alternative water supply resources

**Table 14: Water demand key findings for Witzenberg Municipal SDF, Cape Town Metropolitan SDF and Mangaung Metropolitan Municipal SDF**

| Witzenberg Municipal SDF: Current infrastructure might not be able to supply adequate future demand | | Cape Town Metropolitan Municipal SDF | Mangaung Metropolitan Municipal SDF |
|---|---|---|---|
| Proactively supports water demand programmes, water-wise practices while protecting river corridors, wetlands and catchment areas | Water Master Plan approved in 2015. | Demand-side water management within the metropolitan municipality for the last 15 years | Aims to implement a water demand management system (Mangaung Gariep Water Augmentation Project) |
| | Water Service Development Plan approved in 2019. | Effective demand management measures result in meeting the long-term supply goal. | Alternative water supply sources will have to be secured. |
| Aims to develop | Agricultural water demand management programme | Integrated approach to demand-side water management | Maselspoort Reuse Project: reuse water sources. Rehabilitation of infrastructure is also considered. |
| | Water demand management programme for industrial and settlement nodes | Alternative resources: recycling water and other extraction projects | |
| Reuse of reclamation wastewater | Sewer Master Plan | | |
| | Water Service Development Plan approved in 2019. | | |

Source: Own construction (2021)

### 4.5.5 Stormwater: Key findings and conclusion

KPA 5 revealed that out of a total of 8 scores, 25% (2 scores) achieved A to B and 75% (6 scores) achieved C to D. It is evident that the change in land cover as a means to accommodate land use has a direct impact on stormwater runoff. All four SDFs acknowledge the importance of stormwater runoff infrastructure and the need to incorporate this in the SDF. There is a lack of consideration of the combination of stormwater infrastructure and natural ecosystems as an alternative to manmade waterways. The need for stormwater treatment as an alternative water supply resource is generally not considered.

### 4.5.6 Landscaping: Key findings and conclusion

KPA 6 revealed that out of a total of 4 scores, 50% (2 scores) achieved A to B and 50% (2 scores) achieved C to D. It is evident that landscaping for natural ecosystems is considered in the SDF but there is a lack of implementation. Landscaping can play an important role in water management and result in a more sustainable, water-sensitive urban area. The Cape Town Metropolitan Municipal SDF, Mangaung Metropolitan Municipal SDF and Dawid Kruiper Local Municipal SDF aim to integrate natural water cycles in urban development to enhance cultural, social, ecological and visual values. All SDFs encourage ecological corridor linkages between fragmented and existing natural landscape ensuring protection of water quality. The Dawid Kruiper Local Municipal SDF and Witzenberg Municipal SDF do not make provision for landscaping features to support water management.

### 4.5.7 Cost benefit: Key findings and conclusion

KPA 7 revealed that out of a total of 8 scores, 12.5% (1 score) achieved A to B and 87.5% (7 scores) achieved C to D. This indicates that ecosystem services were not priced in the SDF and only the benefits of ecosystem services were acknowledged.

The Cape Town Metropolitan Municipal SDF makes provision for the creation of a cost-effective, integrated approach to ensure that ecosystems within the City remain intact. The Mangaung Metropolitan Municipal SDF, Dawid Kruiper Local Municipal SDF and Witzenberg Municipal SDF did not the cost of natural ecosystems or manmade infrastructure.

The main conclusion to be drawn here is that WSUD is not considered when developing a new municipal SDF. The cross-case analyses for each KPI suggest that:

- KPI 1.1: The KPI produced two “partially considered or incorporated” (B) and two “minimally considered or incorporated” (C).
- KPI 1.2: Overall this is one of the best performing KPIs with one “fully considered or incorporated” (A), two “partially considered or incorporated” (B) and only one “minimally considered or incorporated” (C).

- KPI 1.3: The KPI produced one “fully considered or incorporated” (A), one “partially considered or incorporated” (B) and two “minimally considered or incorporated” (C).
- KPI 2.1: The KPI produced two “minimally considered or incorporated” (C), one “not considered or incorporated” (D) and one “partially considered or incorporated” (B).
- KPI 2.2: The KPI produced two “minimally considered or incorporated” (C), one “not considered or incorporated” (D) and one “partially considered or incorporated” (B).
- KPI 3.1: The answer to the question as to the extent that the consideration of the water cycle was integrated in the SDF, can be considered “ineffectively”. The KPI produced three “minimally considered or incorporated” (C) and one “not considered or incorporated” (D).
- KPI 3.2: Overall this is one of the best performing KPIs although the KPI produced only one “fully considered or incorporated” (A), two “partially considered or incorporated” (B) and only one “minimally considered or incorporated” (C).
- KPI 4.1: The KPI produced two “not considered or incorporated” (D) and two “partially considered or incorporated” (B).
- KPI 4.2: The KPI produced one “minimally considered or incorporated” (C), one “not considered or incorporated” (D) and two “partially considered or incorporated” (B).
- KPI 5.1: The KPI produced two “not considered or incorporated” (D), one “minimally considered or incorporated” (C), and one “partially considered or incorporated” (B). This is of particular concern since treated stormwater can be used as an alternative water supply.
- KPI 5.2: The KPI produced two “minimally considered or incorporated” (C), one “not considered or incorporated” (D) and one “partially considered or incorporated” (B).
- KPI 6.1: The KPI produced one “not considered or incorporated” (D), one “minimally considered or incorporated” (C) and two “partially considered or incorporated” (B).
- KPI 7.1: The availability of information on the extent to which ecosystems services are priced in the SDF is considered ineffective. The KPI produced three “minimally considered or incorporated” (C) and one “not considered or incorporated” (D).
- KPI 7.2: The KPI produced one “minimally considered or incorporated” (C), two “not considered or incorporated” (D) and one “partially considered or incorporated” (B).

All four of the case studies provide some form of water-sensitive principal support in their SDFs. By prioritising sustainability, resilience, resource security and efficiency Cape Town Metropolitan Municipality is at the forefront of developing more policies related to water sensitivity. The Cape Town Metropolitan Municipal SDF and the municipal IDP are aligned to ensure implementation. The Metropolitan Municipality recognises and confronts water scarcity by developing policies that facilitate the transition to an urban area that is water sensitive. Implementation direction is guided by the newly developed Water Strategy.

In contrast, Dawid Kruiper Local Municipality, Mangaung Metropolitan Municipality and Witzenberg Municipality have taken fewer active approaches to promote sustainable water management. Even though sustainability and resilience are focused on in the SDFs, WSUD is not actively promoted.

# CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

The findings of this study across the previous chapters are summarised in this chapter. From an environmental perspective, it is frequently stressed that investing in sustainability and alternative resources and methods is essential. The importance of incorporating WSUD effectively in municipal SDFs cannot be overemphasised, as it promotes sustainable human settlement. This study examines the incorporation of WSUD in municipal SDFs in South Africa.

This chapter aims to provide a broad summary of the findings concerning the literature review and the empirical investigation as captured in the previous chapters, recommendations for consideration in future studies, and concluding remarks regarding the incorporation of WSUD in municipal SDFs.

## 5.2 Findings

The research led to conclusions regarding the relevance and role of WSUD in municipal SDFs. Chapter 4 established that water resources are impacted by spatial planning and land-use management decisions and activities. Therefore, future water resources can be secured by municipal planning tools that affect water and environmental-related policies, legislations, and plans. The primary goal of this study was to determine the degree to which WSUD improves the environment, water and land in a typical local municipality, in this case, Cape Town Metropolitan Municipality, Mangaung Metropolitan Municipality, Dawid Kruiper Municipality, and Witzenberg Municipality. Based on the initial review of the municipal SDFs, it is evident that WSUD incorporation in local municipalities is insufficient.

Based on this study's literature review, water availability, quantity and quality are hardly ever considered in spatial planning. Although social development and service delivery are high on the South African political agenda, challenges to promote social and economic equity and a sustainable environment, particularly in urban areas, are experienced. A natural-orientated built environment can play a vital role in using ecosystems services in urban areas. This would result in different cost benefits in terms of water management.

## 5.3 Recommendations for a way forward

Water resource and land-use planning have existed side-by-side for decades. Nevertheless, on a municipal scale, these two disciplines have failed to inform each other. Results from the empirical investigation and all other chapters leading up to the empirical investigation prove that

WSUD could secure future water resources by making decision-makers conscious of the impact on water quantity and quality.

This study recommends an integrated approach to address the current water scarcity and water management challenges in South Africa. WSUD aims to supply adequate water resources to meet the demand while protecting water quality in urban areas through sustainable urban development. The implementation of the recommended WSUD must be discussed on different scales of planning, from small to large. To ensure the successful incorporation of WSUD within municipal SDFs, the government needs to offer direction, capacity and policies to support local authorities when designing and planning urban settlements that are water sensitive. WSUD must be incorporated at different scales to achieve incremental growth in sustainable development.

The municipal-level incorporation of WSUD in South Africa was informed by the principles of WSUD as captured in this research (cross-reference to Chapter 3). It was evident that the incorporation of WSUD on the municipal level needed to address the following aspects:

- Develop an integrated land and water management framework that offers technical guidance for urban water management.
- Ensure that land use does not contradict water goals by integrating Water Management and Spatial Planning and ensuring landscape-related aspects are considered in the water planning process/
- Integrate water planning policies and impact assessment procedures to ensure water quality.

The WSUD framework adds objectives, actions, and outcomes by linking the concept of water sensitivity when developing SDFs. Even though SPLUMA mandates each municipality to develop and adopt an SDF, a municipality will seldom consider water sensitivity. A rehabilitation strategy should be developed to prioritise the conservation and protection of natural ecosystems and water resources.

An Ecological infrastructure master plan should be included in all municipal SDFs with a rainwater harvesting strategy should form part of the localised spatial plan. The layout and design of new developments and redevelopments must be adaptable to the surrounding landscapes and areas. This is possible by understanding the natural ecosystem. A demand-side management plan should be developed and implemented and finding alternative water resources should be encouraged. Partnerships with academia can provide various opportunities and meeting with professionals or attending a seminar is key to connect with the different network hubs. The cost of developing infrastructure supporting WSUD can be considerably higher but is more resilient and sustainable. Spatial planning tools can secure future water resources is the quantity and quality of land use water are addressed throughout the MSDF. Further research is recommended to expand the research objectives to include the IDP and locations of the study areas.

## 5.4 Conclusion

The initial conceptualisation of WSUD evolved from stormwater quality management to integrating a holistic broader framework for urban water management. The new paradigm of sustainable urban water management is centred on integration at several levels.

Although several projects have successfully incorporated one or more elements of WSUD, the overall successful incorporation of WSUD varies. The incorporation of excellent WSUD in construction and maintenance practices is identified as a recurring impediment. The primary function of an SDF is planning for future growth. Therefore, municipal SDFs can ensure future water resources by incorporating WSUD. The municipal Water Service Development Plans should address future water demand. Improvement for the integrated management of the urban water cycle remains elusive. A necessary but underdeveloped area of research is the technology distribution efforts and the effective development of policies. Recent studies provide an approach to sustainable urban water management using a WSUD institutional template. By incorporating a framework for WSUD effectively, water resources in South Africa can be managed in a sensitive manner (also referred to as WSUP by Armitage *et al.*, 2014).

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