

**Evidence based water sensitive planning:
Securing water sustainability through
innovative spatial planning tools**

HE Rohr



orcid.org 0000-0003-4944-2398

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Promoter: Prof EJ Cilliers

PREFACE

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ABSTRACT

Everything society does, from its economy to its culture, depends in part on safe, stable access to water resources. However, water resource management looms as one of the greatest global challenges of the 21st century. The fact that South Africa is a semi-arid country characterised by not only low rainfall but also huge variations in the temporal and spatial distribution of precipitation, limited underground aquifers and reliance on significant water transfers from neighbouring nations have made this challenge even more complex. Limited irrigable land and water-intensive electricity generation, unsustainable urbanisation trends and far-reaching political promises have amplified the strain on existing water resources. Furthermore, a 17% water demand-supply gap is expected by 2030 due to economic and population growth, increased urbanisation coupled with unrealistic expectancies of higher standards of living, and climate change. The study argues that every land use has a qualitative and quantitative impact on water resources. Qualitative refers to the pollution factor, and quantitative to the consumption factor. Yet, water-related land use implications are barely ever addressed in spatial planning and land use management documents, as the relationship between land and water is not commonly understood by planning practitioners. This study evaluates the land, water and environmental resources relationship and the impact of physical development (driven by population, urbanisation and economic growth) on these resources. The study reflects on the internationally adopted concept of Water Sensitive Cities (WSC), and recently adopted local concept of Water Sensitive Settlements (WSS). It identifies opportunities as to how municipal spatial planning and land use management practices can, and should, give effect to these concepts. To provide evidence that spatial planning and land use management can secure water sustainability through innovative spatial planning tools, Lephalale and Mogalakwena Local Municipality were selected as case studies. A review of each municipality's existing spatial planning and land use management documents revealed that neither gave effect to the importance of water resources, while the concept of water sensitivity was non-existing. Through extensive data analysis and spatial modelling exercises, it became evident that sustainable water resource planning and management can be achieved through Water Sensitive Spatial Planning. A framework for Water Sensitive Spatial Planning accompanied by a comprehensive guideline on "how to" achieve water sensitivity is therefore proposed for municipal use when local authorities develop their principal spatial planning tools. In doing so, South Africa can secure water sustainability in the near future. Recommendations from this study could also hold equal promise for other urban areas across the globe.

Key terms include: Spatial Development Framework (SDF); Land Use Scheme (LUS); and Water Sensitive Spatial Planning (WSSP).

OPSOMMING

Alles waarmee die gemeenskap te doen het, van sy ekonomie tot sy kultuur, is deels afhanklik van veilige, standhoudende toegang tot waterhulpbronne. Die bestuur van waterhulpbronne is een van die grootste globale uitdagings van die 21ste eeu. Weens die feit dat Suid-Afrika 'n halfdorland is, gekenmerk deur nie slegs lae reënval nie, maar ook aansienlike wisseling in temporele en ruimtelike reënvalverspreiding, beperkte ondergrondse waterdraers en wesenlike steun op watervoorsiening vanuit sy buurlande, is hierdie uitdaging des te meer kompleks. Beperkte besproeibare grond en waterintensiewe opwekking van elektrisiteit, onvolhoubare tendense tot verstedeliking en verreikende politieke beloftes vergroot die druk op bestaande waterhulpbronne. Hierbenewens kan 'n gaping van 17% tussen die vraag en aanbod water teen 2030 te wagte wees, vanweë ekonomiese groei, die bevolkingsaanwas, 'n toename in verstedeliking gepaard met onrealistiese verwagtinge van hoër lewenstandaarde en klimaatsverandering. Die studie voer aan dat alle gebruik van grond 'n kwalitatiewe en kwantitatiewe impak op waterhulpbronne het. Kwalitatief verwys na die besoedelingsfaktor en kwantitatief na die gebruik van water. Grondgebruik wat met water verband hou, word selde in dokumente oor ruimtelike beplanning en bestuur van grondgebruik behandel, aangesien beplanningspraktisyns meestal nie die verband tussen grondgebruik en water verstaan nie. Die studie beoordeel die verhouding tussen grond, water en omgewingshulpbronne, asook die invloed van fisiese ontwikkeling (aangevoer deur bevolkingsaanwas, verstedeliking en ekonomiese groei) op sodanige hulpbronne. Die studie besin oor die internasionaal aanvaarde begrip van watersensitiewe stede (Water Sensitive Cities – WSC) en die onlangs aanvaarde Suide-Afrikaanse begrip van watersensitiewe nedersettings (Water Sensitive Settlements – WSS). Die studie identifiseer geleenthede vir die wyse waarop munisipale ruimtelike beplanning en bestuur van grondgebruik, uitvoering kan gee, en behoort te kan gee, aan sodanige konsepte. Ten einde bewys te lewer dat ruimtelike ontwikkeling- en bestuur van grondgebruik die volhoubaarheid van water verseker, veral in terme van innoverende werktuie vir ruimtelike beplanning, is die Lephalale en Mogalakwena Plaaslike Munisipaliteit as gevallestudies aangewend. Uit 'n oorsig van elke munisipaliteit se bestaande dokumentasie oor ruimtelike ontwikkeling en bestuur van grondgebruik blyk dit dat dit nie uitvoering aan die gewigtigheid van waterhulpbronne verleen nie, asook dat geen aandag aan die begrip van watersensitiwiteit geskenk word nie. Uit uitvoerige toetse ten opsigte van data-ontleding en ruimtelike ontwikkeling het dit duidelik geblyk dat volhoubare waterhulpbronbeplanning en -bestuur haalbaar is by wyse van Watersensitiewe Ruimtelike Beplanning en Bestuur van Grondgebruik. 'n Raamwerk vir watersensitiewe ruimtelike beplanning, met omvattende riglyne oor hoe watersensitiwiteit bewerkstellig kan word, word derhalwe vir munisipale gebruik voorgehou wanneer plaaslike

owerhede hulle hoofwerktuie vir ruimtelike ontwikkeling daarstel. Hierdie bydrae wat voorspruit uit hierdie studie sal beteken dat Suid-Afrika sodoende volhoubare water in die nabye toekoms sal kan verseker. Verdere aanbevelings voortspruitend uit hierdie studie kan ook soortgelyke beloftes inhou vir ander stedelike gebiede oor die wêreld heen.

Sleutel terme sluit in: Ruimtelike Ontwikkelingsraamwerk; Grondgebruikskema; en Water Sensitiewe Ruimtelike Beplanning.

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LIST OF ABBREVIATIONS

ARC	Agricultural Research Council
BGIS	Biodiversity GIS
BMP	Biodiversity Management Plan
CBA	Critical Biodiversity Areas
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
CoGTA	Co-operative Governance and Traditional Affairs
DEAT	Department of Environmental Affairs and Tourism
DWS	Department of Water and Sanitation
EI	Ecological Infrastructure
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
ESA	Ecological Support Area
FEPA	Freshwater Ecosystem Priority Area
GI	Green Infrastructure
GIS	Geographic Information System
IDP	Integrated Development Plan
ILI	Infrastructure Leakage Index
ISRDP	Integrated Sustainable Rural Development Programme
ISRDS	Integrated Sustainable Rural Development Strategy
IWRM	Integrated Water Resource Management
MLUS	Municipal Land Use Scheme
NBF	National Biodiversity Framework
NDP	National Development Plan
NEMA	National Environmental Management Act
NFEPA	National Freshwater Priority Area
NRW	Non-Revenue Water
NSDF	National Spatial Development Framework
NSDP	National Spatial Development Perspective
NWA	National Water Act
NWRS	National Water Resource Strategy
RDLR	Department of Rural Development and Land Reform
SANBI	South African National Botanical Institute

SDF	Spatial Development Framework
SPLUMA	Spatial Planning and Land Use Management Act
SuDS	Sustainable Urban Drainage Systems
URP	Urban Renewal Programme
VIP	Ventilated Improved Pit Latrine
WMA	Water Management Area
WRC	Water Research Commission
WSA	Water Services Authority
WSC	Water Sensitive Cities
WSDP	Water Services Development Plan
WSLUS	Water Sensitive Land Use Scheme
WSP	Water Services Provider
WSS	Water Sensitive Settlements
WSSDF	Water Sensitive Spatial Development Framework
WSSP	Water Sensitive Spatial Planning
WSUD	Water Sensitive Urban Design
WTW	Water Treatment Works
WWTW	Wastewater Treatment Works

DEFINITIONS

Table 0-1 provides a summary of words and terms relevant to the study:

Table 0-1: Glossary

Word / term	Description
Aquifer	A geographical formation which has structures or textures that hold water or permit appreciable water movement through them as defined in Act No. 36 of 1998.
Biodiversity / biological diversity	The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part and includes diversity within species, between species, and of ecosystems as defined in the Act No. 10 of 2004.
Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted to reduce the impact of adjacent land uses on the wetland or riparian area.
Catchment	Means the area from which any rainfall will drain into the watercourse or watercourses or part of a water course through surface flow to a common point or common points as defined in Act No. 36 of 1998.
Critical Biodiversity Areas	Areas required to meet quantitative targets for biodiversity, as determined by an integrated terrestrial and aquatic systematic biodiversity plan. These areas are critical for conserving biodiversity and maintaining ecosystem functioning in the long term as defined in Act No. 10 of 2004.
Ecological infrastructure	Refers to naturally functioning ecosystems that deliver valuable services to people, such as healthy mountain catchments, rivers, wetlands, coastal dunes, and nodes and corridors of natural habitats, which together form a network of interconnected structural elements in the landscape. Ecological infrastructure is therefore the asset, or stock, from which a range of valuable services flow.
Ecological Support Areas	These are areas that play a significant role in supporting ecological functioning of Critical Biodiversity Areas and/or delivering ecosystem services as determined in a systematic biodiversity plan as defined in Act No. 10 of 2004.
Ecosystem	Means a dynamic system of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit as defined in the National Environmental Management Biodiversity Act No. 10 of 2004.
Ecosystem services	Are the benefits that people obtain from ecosystems, including provisioning services (such as food, water, reeds), regulating services (such as flood control, cultural services (such as recreational fishing), and supporting services (such as nutrient cycling carbon storage) that maintain the conditions for life on Earth.
Evidence based	Denoting an approach to medicine, education, and other disciplines that emphasizes the practical application of the findings of the best available current research.
Freshwater ecosystems	Are all inland water bodies whether fresh or saline, including rivers, lakes, wetlands, sub-surface waters and estuaries. The incorporation of groundwater considerations into the FEPA maps was rudimentary and future refinement of FEPA should seek to include groundwater more explicitly.
Land use scheme	Means the documents referred to in section 24 of Act No. 16 of 2013 for the regulation of land use.
Municipality	Is referred to as an entity, meaning a municipality as described in the Municipal Systems Act No. 32 of 2000, and a geographic area, means a municipal area determined in terms of Act No. 27 of 1998.
Spatial Development Framework	Means spatial development framework referred to in section 21 of Act No.16 of 2013

Systematic biodiversity planning	Systematic biodiversity planning is a strategic and scientific approach to identifying those areas that are the most important for biodiversity conservation.
Spatial Planning	Refers to all aspects of the of South Africa's Spatial planning system as per Section 4 of Act 16 of 2013.
Water Conservation and Water Demand Management (WC/WDM)	Is an approach in water resource management that seeks to improve water use efficiency through using available water more wisely and through seeking appropriate and cost-effective technologies that reduce wasteful use. Water demand management encourages efficient use by encouraging users to reduce their demands on the resource.
Water security	The reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks.
Water sensitive	See chapter 3, subsection 3.4.
Wetland	Means land which is transitional between terrestrial and aquatic systems where the water table is usually on the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

Source: South Africa (1998a); South Africa (2004); South Africa (2013); DWAF (2005); Western Cape (2014); SANBI (2014a); DWAF (2006); Lexico (2019) and Grey & Sadoff (2007).

UNIT OF MEASUREMENT

ha: Hectare
km: Kilometre
km²: Square kilometre
m³: Cubic metre
m³/d: Cubic metre per day
m³/a: Cubic metre per annum
m: Metre
mm: Millimetre
mm/yr: Millimetre per year
R: Rand

CHAPTER 1 INTRODUCTION

1.1 Context and significance of the study

Everything society does, from its economy to its culture, depends in part on safe, stable access to water resources. This dependency causes impact – an impact that is both qualitative and quantitative. As society grows, so will the qualitative and quantitative impact on water resources. By 2050, the global population figure is predicted to reach 9.7 billion (UN DESA, 2015:1-2), of whom more than 70% will most likely reside in urban areas (UN DESA, 2018:1).

Qualitative impact – Angel *et al.* (2011:49) anticipate that for urban areas to accommodate this growth, urban land cover will double in developed countries and expand by 326% in developing countries. This need for space will trigger rapid land cover change, abolishing natural landscapes and ecological infrastructure. According to Lambin *et al.* (2001:262) “land-use and land-cover changes are so pervasive that, when aggregated globally, they significantly affect key aspects of Earth system functioning”. On the local level, changes in land use and land cover alter the rate and functionality of the well-known natural cycle of replenishment and the hydrological responses of watersheds (Verburg, Neumann, & Nol, 2011:974; Chapin, *et al.*, 2000:234; Jetz, *et al.*, 2007:1216). Furthermore, anthropological land-use and associated cover, including urban, agriculture and mining practices, also contributes to non-point source pollution of runoff (WRC, 2016:8; Nel, *et al.*, 2011:5; DWA, 2013a:39-41). As natural landscapes no longer exist, soils and vegetation can no longer filter and treat polluted runoff. As a result, untreated, polluted runoff enters larger remaining water bodies, including wetlands, rivers, estuaries, and groundwater aquifers. In effect, good quality water bodies will become increasingly more polluted, resulting in water quality deterioration imposing high risks to human health, economic development and ecosystem sustainability (WWAP, 2017:20). Land-use and land-cover change is also a major trigger of climate change. According to Zhang & Yan (2014:595) this climate phenomenon has caused Earth’s drylands surface areas to double since the 1970s. Furthermore, the Intergovernmental Panel on Climate Change (IPPC) (2014:4-7) reports that the predicted change will cause more frequent and extreme climate events such as droughts and storm surges, making freshwater resources most vulnerable to climate change.

Quantitative impact – According to Postel *et al.* (1996:787) society uses 54% of the global available fresh water. In 2016, the FAO (2016a) reported that water withdrawal increased 7.3 times over the last century – increasing 1.7 times faster than the world population growth.

The predicted increase in population, and more specifically urban population, will cause total water demand for adequate municipal, industrial and agricultural supply to increase by up to 70% by 2050 (Bradley, *et al.*, 2002:60-63; Falkenmark & Lindh, 1974:116; Falkenmark & Widstrand, 1992:25-36; McDonald, *et al.*, 2011:444-445). Increased consumption of water resources has become the norm in many cities such as Johannesburg (South Africa), which consumes ten times the World Health Organization's (WHO) daily recommendation (UN Habitat, 2013:70). Many argue that this elevated demand and usage of water is due to the high level of service provided in urban areas through conventional water infrastructure systems (Hobbs, *et al.*, 2006:4-6). While this system has been the sought-after solution for many decades – many criticize the system for being fragmented, lacking flexibility, being energy intensive, and cost-inefficient in the long run (SWITCH:2011).

Global trends indicate that increased water usage and wastewater generation currently exceed the rate at which conventional wastewater treatment plants can operate (IWMI, 2007:8). As a result, only 20% of globally produced wastewater receives proper treatment (UNESCO: 2012). Furthermore, every conventional water infrastructure network has an Unavoidable Annual Real Loss (UARL). It represents the minimum level of real water losses for a specific system that can be achieved under the most efficient operating conditions (McKenzie & Seago, 2005:5). The UARL considers, amongst others, the length of mains and the density of service connections. By this description, any land use decision regarding its density and location is therefore a determining factor in the volume of UARL in a system. As some cities are anticipated to expand by 326% (Angel, *et al.*, 2011:49), the location and density of expected land use will be a major determining factor in the average volume of water lost in a system.

The combined effects of population growth and rapid urbanisation – contributing to the rapid transformation and occupation of land; increased levels of consumption and waste production, water loss and depleting water quality – has made the renewability factor of water resources increasingly questionable (Marsalek, *et al.*, 2006:3). It is evident that land-use and land-cover change has both a qualitative and quantitative impact on water. Yet, land use decisions made by spatial planners barely ever consider the water related implication thereof. Furthermore, Wong & Brown (2008:2) state that the conventional urban water management approach has become highly unsuited to addressing current and future sustainability issues due to the physical and institutional compartmentalisation of municipal systems.

In response to the above, the aspirational concept of the Water Sensitive City, pioneered by Australians Brown *et al.* (2008), emerged as an alternative and sustainable approach to water resource planning and management within the broader urban environment.

Water Sensitive Cities seek to readdress the relationship between the urban water system and land by integrating natural and sustainable technology in the design and planning of urban environments (Hillen & Dolman, 2015:2-3). It calls for a paradigm shift in which water is recognised as an important aspect and asset in the planning of cities, thereby bringing together the expertise of spatial planners, landscape architects, urban designers, urban water managers, hydrologist, ecologist and sociologists.

South Africa's journey towards water sensitivity started in 2011 when the Water Research Commission (WRC) solicited research proposals aimed at guiding urban water management decision-makers on the use of Water Sensitive Urban Design (WSUD) in South Africa's context. In 2014, the WRC published the Water Sensitive Urban Design for South Africa: Framework and Guideline document which defines water sensitivity in South Africa as "... the management of the country's urban water resource through the integration of various disciplines of engineering, social and environmental science – whilst acknowledging that: South Africa is water scarce; access to adequate potable water is a basic human right; the management of water should be based on a participatory approach; water should be recognised as an economic good; and water is a finite and vulnerable resource, essential to sustain all life and supporting development and the economy at large" (Armitage *et al.*, 2014:ii). The framework identified the lack of council-approved policies with political backing and the force of law as one of South Africa's major challenges in transitioning towards Water Sensitive Settlements. It also noted that there is untapped potential for more extensive coordination which could be facilitated by the urban and strategic planning fora (Armitage *et al.*, 2014:iii).

In this regard, spatial planning and land use management were identified as key practices through which water sensitivity can be achieved, as its purpose is to guide all future developments (implications for future water resources demand) and regulate the legality of all exiting land uses (existing water quality and quantity impact). Current realities reveal, however, that there is limited integration between land use planning and water resources management, even though the relationship is clear-cut. South Africa's newly enacted Spatial Planning and Land Use Management Act No. 16 of 2013 (SPLUMA) provides Urban and Regional Planners the opportunity to develop water sensitive spatial planning and land use management tools to legally enforce the transformation of water-wasteful settlements to water sensitive settlements. To date, information remains limited as to exactly how spatial planning tools can be used to give effect to water sensitivity, specifically within the South African context. Identifying opportunities within the legislative framework of SPLUMA as to how spatial planning and land use management can give effect to water sensitivity is new to the field of urban studies (specifically in South Africa), and is desperately needed in order to secure sustainable water resources for future generations.

1.2 Problem statement

Spatial planning and land use management in South Africa barely ever take water resources planning and management into account. According to Armitage *et al.* (2014:2) this should mainly be blamed on the “fragmented silo-management of different aspects of the urban water cycle which occurs, in part, because of allocation of different responsibilities to different municipal departments”. This thesis argues that a lack of understanding of the close relationship between the impact of land use on water quantity and quality forms part of this problem.

This study examines the implications of land use decisions on the quantity and quality of water resources, and identifies new ways through which spatial planning and land use management tools can give effect to the concept of water sensitivity in order to achieve future water resource sustainability.

1.3 Primary research question

The primary research question posed by this study is articulated as follows:

- How can water sustainability be secured through innovative and evidence based spatial planning and land use management practices?

The secondary research questions posed by this study include:

- What is the relationship between land, water and environmental resources and in what way have anthropological activities affected water resource quality and quantity on a global scale?
- How has South Africa’s hydrosocial contract affected water resource availability and in what way have spatial development trends contributed to South Africa’s status quo?
- How can South Africa's existing legislative framework for water, the environment and land use give effect to the internationally and locally adopted concept of water sensitivity?
- More specifically, how can innovative spatial planning and land use management tools within the legislative framework of the Spatial Planning and Land Use Management Act (Act 16 of 2013) progressively intervene to secure future water resources availability on local municipal level?

1.4 Aims and objectives of this study

The primary research aim is to develop innovative and evidence based tools through which spatial planning and land use management practices can secure future water resources.

Study objectives:

- Establish a clear understanding of the interdependent relationship between land, water and environmental resources and the impact of anthropological interferences on future resources;
- Carry out a hydrosocio literature review to understand the impact of national political development objective on spatial planning, land use, water and environmental resource planning and management;
- Carry out a legislative and policy analysis to identify which strategic planning instruments can and must be used to inform Water Sensitive Spatial Planning (WSSP), down to municipal level; and
- Determine the extent to which exiting spatial planning and land use management tools give effect to WSSP.

The empirical investigation objectives:

- Provide a new and innovative evidence based methodology on how to determine the land use water quantity impact;
- Provide a new and innovative evidence based methodology on how to determine the land use water quality impact;
- Develop a practical guideline for all Urban and Regional Planners on how to compile a Water Sensitive Spatial Development Framework (WSSDF) and a Water Sensitive Land Use Scheme (WSLUS);
- Establish a framework for Water Sensitive Spatial Planning in South Africa; and
- Produce a guideline on how to develop and implement a Municipal WSSDF and a Municipal WSLUS within the legal framework of SPLUMA.

1.5 Research Methodology

The succeeding section describes the methodology employed in the literature review completed, followed by a section clarifying the empirical research design employed.

1.5.1 Literature review

“The literature review comprises a critical part of the research process, as an analysis of exiting literature frames the subject with regards to established knowledge and exposes shortcomings yet to be addressed” (Lategan, 2017). The aim of the literature review was to gather and review exiting literature and non-empirical data relating to the research questions.

The literature review was informed by published academic articles, books, book chapters, conference papers, thesis and grey literature in terms of South African and international policy and legislation, reports, strategic plans, surveys, census data addressing the interrelationship between anthropological land use (also referred to as land use change) and the impact thereof on water resources quality and quantity.

Literature sources were mainly collected from electronic databases accessed via the North-West University's Ferdinand Postma Library portals. Databases included, among others, ScienceDirect, EBSCOhost, Emerald Insight journals, JSTOR, SAePublications and Google Scholar.

Fundamentally search terms included variations on sustainable spatial planning (international and national policies, multinational agreements; agenda's and goals; national development plan); sustainable cities (compact cities; smart growth; green urbanism; eco-cities; green cities; resilient cities); land use change (population growth; urbanisation; pace of land use change; ecological impact of land use change; growth management; density development); land use management (zonings; buffers; overlays; development controls; green building controls); urban water infrastructure (decentralised and centralised water infrastructure; services delivery; levels of services; affordability of levels of services; non-revenue water); integrated water resources planning (catchment management strategies; integrated development planning; spatial development frameworks; water services development plans; water allocation plans; water reconciliation strategies); water resources (availability of surface and groundwater resources; quality of water resources; land use impact on water resources; future demand for water resources; climate change impact on water resources); water sensitive planning and urban design (origin; principals; design; guidelines; sustainable urban drainage system; green infrastructure; rainwater harvesting; stormwater harvesting; water reuse; water conservation and demand management; optimal design and density development; alternatives to sanitation services); systematic biodiversity planning (bioregional and biodiversity sector plans; ecological infrastructure; freshwater ecosystem priority areas); spatial modelling (water resources modelling; rainwater harvesting modelling; land use and density modelling; land use water quality impact modelling; and growth modelling) and transdisciplinary approaches to resources management.

After obtaining the literature, each text was reviewed, processed and arranged according to theme or timeline. As such, this study presents both a thematic and chronological literature review.

The thematic literature review investigates the following themes:

- Theme 1: Understanding the land water resource relationship;
- Theme 2: Understanding the impact of anthropological interferences on Earth's natural systems and Earth's natural resources;
- Theme 3: Understanding the future water resource implications;
- Theme 4: Understanding South Africa's water resource situation;
- Theme 5: Understanding South Africa's regulatory and strategic planning framework for land, water and environmental resources; and,
- Theme 6: Understanding the concept of water sensitivity within the framework of spatial planning and land use management.

The chronological literature review investigates the conceptual development of South Africa's hydrosocio contract and reflects of the following:

- Timeframe 1700 - 1990: South Africa's early era of industrialisation and urbanisation - reflecting on new departures in urban and regional planning during 1913 -1935; the adoption and implementation of racial legislation with spatial implication during 1936 – 1980; and, various factors that caused increased water demands during 1956 – 1987;
- Timeframe 1950 - 1992: International “calls” for sustainable development 1950 – 1992 - reflecting on the global green generation which emerged during 1962 – 1987; the concept of Integrated Water Resource Management during 1977-1992; and, declarations towards sustainable development 1980-1992;
- Timeframe 1990 - 2000: South Africa's dawn of democracy - reflecting on new government structure and new legislation impacting and land, water and environmental resources; and,
- Timeframe 2000 - 2016: South Africa's key socio-economic development strategies adopted during 2000 and 2016 and the impact thereof on land, water and environmental resources - reflecting on South Africa's existing challenges and opportunities towards sustainable development regarding land, water and environmental resources planning and management.

The findings of the literature review were informed by an ethnographic and observational research method to determine the root cause of South Africa's water related issues and challenges. The literature review was a direct influence on the empirical study, directly producing an informed and appropriately targeted empirical research design.

1.5.2 Empirical investigation

This study draws primarily on qualitative and quantitative research in the case studies of Lephalale and Mogalakwena Local Municipality. The case study research is comprised of four chief components.

Qualitative, the study references to a self-evaluation assessment to determine the extent to which existing planning documents comply with SPLUMA and gives effect to the concept of water sensitivity; a self-evaluation assessment of all national, provincial and local government legislation, policies and plans posing development directive for land, water and environmental resources planning and management; and semi-structured meetings held with Reference Group Members of the WRC Research Project no. K5/2587. Quantitatively, the study applied a integrate systematic analysis of spatial dimensions (population patterns, land use and water) through GIS software, GIS data and other numeric data source. Figure 1-1 illustrates the components of the empirical investigation consisting of three phases informed by various research methods. This structure of investigation was applied throughout Chapter 5.

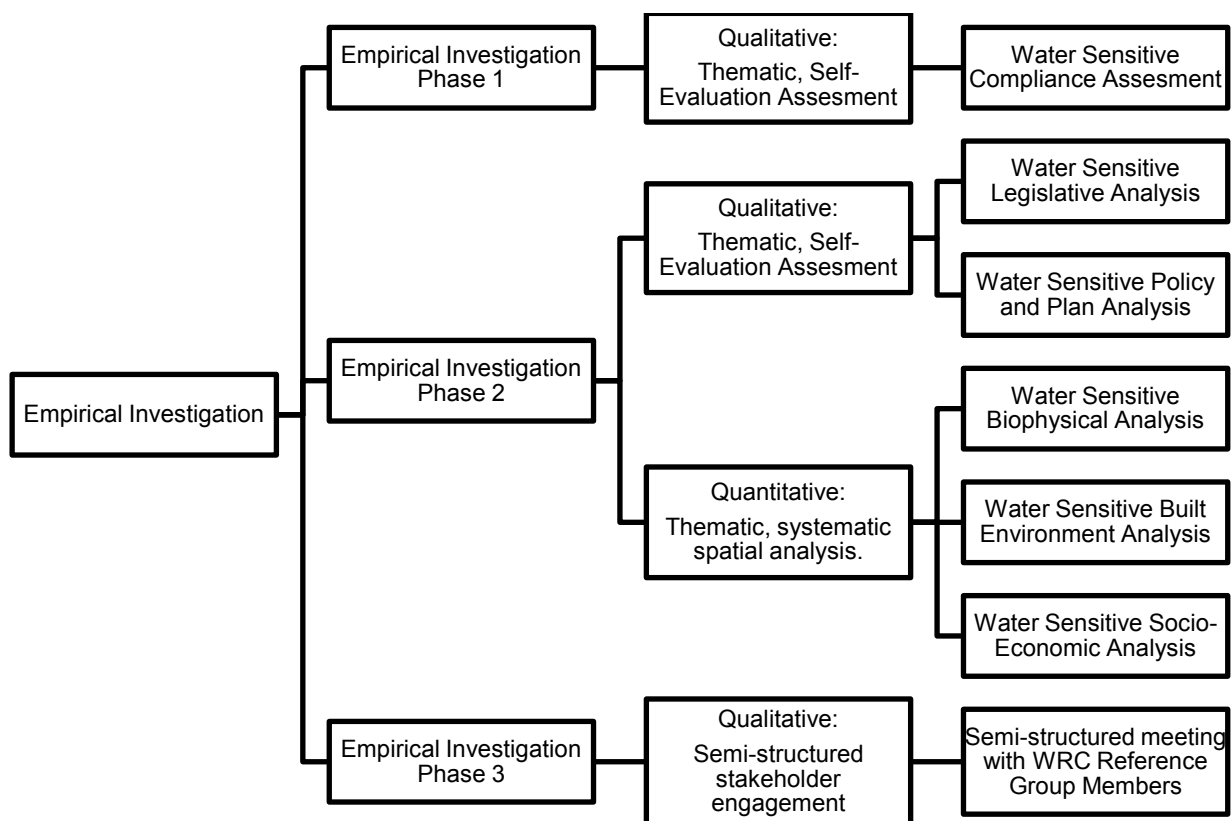


Figure 1-1: Empirical Investigation - research structure

Source: Own Construction (2018)

1.5.2.1 Thematic, self-evaluation: Water Sensitive Compliance Assessment

The study applied a self-evaluation assessment of both Lephalale and Mogalakwena's existing SDFs and LUSs to determine "how well" these planning tools comply with SPLUMA requirements and "who well" do they give effect to concept of water sensitivity. First, the criteria against which the plans will be measured was established.

The criteria were informed by SPLUMA requirements for SDFs and LUSs as well as the concept of water sensitivity, as gathered from the literature review. A colour coded ranking scale was assigned to the framework, differentiating between Green (Adequate: the planning document analysis the specific variable adequately); Yellow (Moderately addressed: the planning document does address the specific issue in question, but not is as much detail as would be desired); and, Red (Not at all: The issue is not addressed in the planning document whatsoever). Section 5.3.2 elaborates of the design and details on the Water Sensitive Compliance Assessment research method.

1.5.2.2 Thematic, self-evaluation: Water Sensitive legislative and policy context analysis

The study applies a thematic self-evaluation assessment of all existing legislation, policies and strategic planning documents adopted in South Africa, that engage with issues affecting land, water and environmental resource planning and management within the selected case study demarcation. The researcher identified and reviewed 109 documents (legislation, policies, plans) based on their description which may suggest that the document can impose development directives for either land, water or environmental resource planning and management within the selected case study demarcation. The thematic self-evaluation assessment consists of tables summarising the themes related to the vision, objective, development directives, regulations, targets and other elements engaged with land, water and environmental resources planning and management. Section 5.4.1 elaborates on the design and details of the Water Sensitive Legislative and Policy Context Analysis research method.

1.5.2.3 Thematic, systematic spatial analysis: Water Sensitive Spatial Analysis

The study applied a quantitative research method based on the systematic analysis of spatial dimensions (population patterns, land use and water) through GIS software, GIS data and other numeric data source (Le Gates, 2005). Through ArcGIS Desktop 10.6.1, the researcher was able to use ArcMap, ArcCatalog, and ArcScene to create maps, perform spatial analysis, and manage geographic data, ultimately to derive and evidence based results. Various spatial data-sets representing information relevant to determining the land use water resources quality and quantity impact were obtained from national departments (e.g. DWS, RDLR and DAFF) and research institutions (e.g. ARC, SANBI and BGIS). Annexure E provides a list of all datasets used during the empirical investigation and where they were obtained from. Non-spatial, but numerical data was provided by the municipal officials from each municipality. The analysis derived at three themes of investigation, biophysical, built environment and socio-economic. These themes also relate to the typical process of developing a SDF and LUS as prescribed by the RDLR (2014) and RDLR (2017). Therefore, the process which the empirical investigation adopted during phase 2.1

and 2.2 will be easily understood by Spatial Planners familiar with the process of developing a SDF and a LUS. Section 5.4.2 elaborates on the design and details of the Water Sensitive Spatial Analysis research method.

1.5.2.4 Stakeholder engagement: WRC Research Project no. K5/2587

This study gained the opportunity to be presented at five of the WRC Research Project no. K5/2587 semi-structured reference group meetings. The focus of the reference group meetings was to build a platform of inter-disciplinary knowledge which integrates concepts and topics related to spatial planning and land use management; water sensitive urban design; sustainable urban drainage systems; municipal engineering and services delivery; systematic biodiversity planning; green infrastructure; urban ecology; municipal finance; national law and regulations related to spatial planning, land use management and water resources planning and management. The aim of the Reference Group meetings was to gain expert inputs in developing a Framework for Water Sensitive Spatial Planning and to derive a practical guideline on how to integrate the concept of water sensitivity into municipal spatial planning and land use management tools.

The reference group consisted of representatives from the Department of Water and Sanitation (Director at the Department of Water and Sanitation; Chief Director: Policy & Strategy Co-ordination; Director: Knowledge Management at the Department of Water and Sanitation); the Department of Rural Development and Land Reform (Chief Town and Regional Planner: Environmental Planning at Department of Rural Development and Land Reform); Department of Agriculture, Forestry & Fisheries (Director: Land Use and Soil Management); A representative from City of Johannesburg (Assistant Director: Open Space Planning at City of Johannesburg); City of Tshwane (Chief Engineer); eThekweni Metropolitan Municipality (Snr. Manager Planning: Water and Sanitation); expert SPLUMA consultant (Director at i@Consulting); and two experts in the field of research on matters related to water sensitive development (Director at Water Research Commission and Research Coordinator at Future Water Research Institute). Table 1-1 lists the names of key reference group members, their positions and contact details. Each meeting was recorded. The Reference Group Meetings added valuable supportive information and a more nuanced understanding of the issues under consideration.

Table 1-1: WRC Project No. K5/2587 Reference group

Reference group	Position	Contact details
Mr J Bhagwan (Chairperson)	Director at Water Research Commission	jayb@wrc.org.za
Mr W Fourie	Director at i@Consulting Pty Ltd. Professional registered Town Planner	Werner@iatconsulting.co.za
Mr G Van Vuuren	Chief Engineer at City of Tshwane	gawievv@tshwane.gov.za
Ms J Eagle	City of Johannesburg Assistant Director: Open Space Planning at City of Johannesburg	JaneE@joburg.org.za
Dr C Carden	Research Coordinator at Future Water Research Institute	Kirsty.Carden@uct.ac.za
Mr ME Mhlanga	Chief Town and Regional Planner: Environmental Planning at Department of Rural Development and Land Reform	MEMhlanga@ruraldevelopment.gov.za
Mr F Van Zyl	Director at the Department of Water and Sanitation	vanzylF@dwa.gov.za
Ms A Collet	Department of Agriculture, Forestry & Fisheries (DAFF) - Directorate: Land Use and Soil Management	annelizac@daff.gov.za
Ms M Brisley	DWS National Disaster Management: Chief Director: Policy & Strategy Co-ordination	BrisleyM@dws.gov.za
Ms D Segoale	Director: Knowledge Management at the Department of Water and Sanitation	SegoaleD@dws.gov.za
Mr S Moodliar	eThekweni Municipality Snr. Manager Planning: Water and Sanitation at eThekweni Municipality	Speedy.Moodliar@durban.gov.za

Source: Own Construction (2018)

Section 5.5 provides a full discussion on the contributions made by the reference group members during the semi-structured meetings.

1.6 Structure of study

Figure 1-2 is a representation of the structure of the research method used to conduct this study.

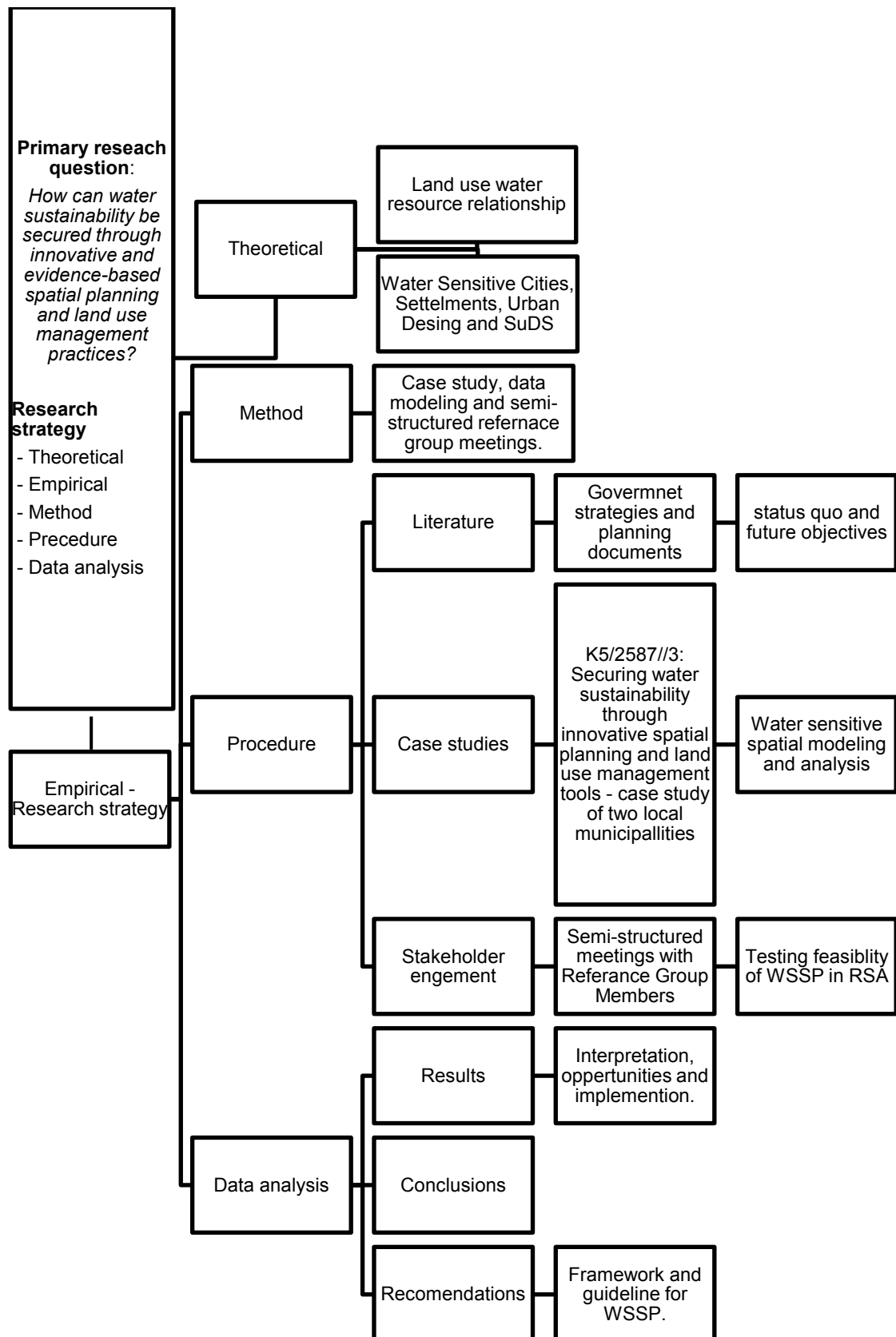


Figure 1-2: Conceptual model of the research process

Source: Own Construction (2018)

This section provides a summary of the structure and content of the remainder of the thesis.

Chapter 2 investigates the global relationship between development, water and the environment. Water is a renewable natural resource as it operates within a closed-loop system called the hydrological cycle. In engineered environments like towns and cities, humans have a significant influence on the local hydrological cycle, by introducing artificial surfaces and man-made engineered infrastructure that have had both a quantitative and qualitative impact on water resources and the ecosystems that depend on them. Land-based activities are much to blame for loss of the country's ecological infrastructure and the state of water resources. Accordingly, this chapter establishes the close relationship between development driven by anthropological needs and its impact on water resources and the broader environment.

Chapter 3 contextualises South Africa's hydrosocio contract. The notion was first introduced by Turton & Ohlsson (1999) at the 9th Stockholm Water Symposium. It is well known that South Africa's political history has shaped the country's landscape into two distinctive urban and rural environments. The "apartheid city" is a well well-known case study often cited as one where politics have a detrimental impact on spatial planning. However, the impact of this politically driven apartheid agenda on water resource is less familiar to South Africa broader planning fraternity. Thus, this chapter investigates the relationship between South Africa's land development policies and water resource planning and management. It also examines international development trends to establish a timeline of changing paradigms in terms of urban planning and water resources planning and management.

Chapter 4 provides insight into strategic planning for land, water and environmental resources. It follows Chapter 2, which established the close relationship between land, water and the environment. However, despite this close relationship it argues that urban and regional (people and land) and environmental resource management (water and the broader environment) is typically governed by different sector departments, often to the detriment of sustainable development. This Chapter introduces the concept of water sensitivity and provides a thorough investigation of South Africa's legal case for spatial planning and land use management. This Chapter aims to identify opportunities within the legislative requirement of SPLUMA as to how and to what extent spatial planning and land use management can give effect to the concept and practice of water sensitivity.

Chapter 5 presents a case study of two local municipalities as a basis for the empirical investigation. It describes the specific empirical approach used, the details of the desktop study, and new methodologies as to how spatial planning and land use management can give effect to

water sensitivity. This chapter applies theory to practice and concludes with several key findings related to gaps and opportunities for WSSP.

Chapter 6 sets the conclusion of this thesis with specific references to the opportunities for WSSP in South Africa. It provides a synopsis of the finding of each Chapter and concludes by addressing the primary research question and research objectives.

Chapter 7 translates the research findings into a proposed Framework for Water Sensitive Spatial Planning and a practical Guideline for compiling water sensitive spatial plans.

1.7 History and contextualisation of study

In recent years, calls for cross-sectoral coordination and integrated planning approaches echoed across different fields of planning. In 2011, WRC solicited research proposals aimed at guiding urban water management decision-makers on the use of Water Sensitive Urban Design (WSUD) in a South African context. This soon led to the publication of “The South African Guideline for Sustainable Drainage Systems” (hereafter referred to as the SuDS Guidelines) in 2013, which emanated from a WRC funded research project entitled, 'Alternative technologies for stormwater management' (WRC Project No. K51/1826). The following year, the WRC published the “Water Sensitive Urban Design for South Africa: Framework and Guidelines” (hereafter referred to as the WSUD Framework) which emanated from a project entitled Water Sensitive Urban Design (WSUD) for improving water resource protection / conservation and re-use in urban landscapes (WRC Project No. K5/2071). The framework introduces the philosophy of WSUD in South Africa and defines water sensitivity as “...the management of the country’s urban water resources through the integration of the various disciplines of engineering, social and environmental sciences – whilst acknowledging that: South Africa is water scarce; access to adequate potable water is a basic human right; the management of water should be based on a participatory approach; water should be recognised as an economic good; and water is a finite and vulnerable resource, essential to sustaining all life and supporting development and the environment at large” (Armitage *et al.*, 2014:ii).

Based on this definition, the Framework adopted the new term, “Water Sensitive Settlements (WSS)”, to incorporate South Africa’s broader range of settlements types (Armitage *et al.*, 2014:17). The framework identified three components of WSUD to be considered in an integrated manner towards achieving WSS. They include “Water Sensitive Urban Design, WSUD (ensuring ‘urban design’ is undertaken in a ‘water sensitive’ manner); Water Sensitive Urban Planning, WSUP (high-level urban planning and governance); and Water Sensitive Urban Management, WSUM (management of infrastructure supporting the urban water cycle) (Armitage *et al.*, 2014:iv).

While both the SuDS Guideline and the WSUD Framework provide abundant information on detailed designs of SuDS, information remained limited regarding the function of WSUP in achieving WWS.

As a result, the WRC embarked on a new research project to bring WSUD, as defined and envisioned by the WSUD Framework, into the larger municipal planning environment. Based on this study's aims and objectives, the WRC awarded a new research project (K5/2587) entitled, 'Securing water sustainability through innovative spatial planning and land use management tools: Case study of two local municipalities in 2016'. During 2016 and 2019, more than nine reference group meetings were held with leaders in the field of land, water and environmental resource planning and management. K5/2587 produced seven research documents, each of which was presented, discussed and workshopped with the reference group members.

The final two documents have been earmarked for formal publication by the WRC as deliverable 6 signifying a *Framework towards water sensitive spatial planning and land use management*, while deliverable 7 provides a *Guideline on compiling water sensitive spatial plans*. The author of this study was the head researcher and author of the WRC Research funded Project no. K5/2587 – therefore this study presents a synopsis of the seven research documents.

To contextualise this study in more detail, the following should be considered. In June 2015, Parliament enacted a new planning legislation – the Spatial Planning and Land Use Management Act 16 of 2013. Today, this Act is South Africa's only framework act that regulates and guides spatial planning and land use management for the entire country. The act mandates all local municipalities to develop and adopt a Municipal Spatial Development Framework (MSDF) and a Municipal Land Use Scheme (MLUS) for its entire municipal area within five years of the enactment of SPLUMA. The MSDF and the MLUS are planning tools designed to guide the future shape of a municipality and to lawfully administer and regulate land use – both of which carry water related implications. To give effect to SPLUMA, and to achieve water sensitivity within the broader municipal planning environment, this dissertation adopted a new term, 'Water Sensitive Spatial Planning (WSSP)', as it relates to the entire municipal area instead of just the urban environment. This study aims to achieve WSSP through two planning tools, which include the development and implementation of a Water Sensitive Spatial Development Framework and a Water Sensitive Land Use Scheme. Figure 1-3 is a representation of the conceptual framework of the study.

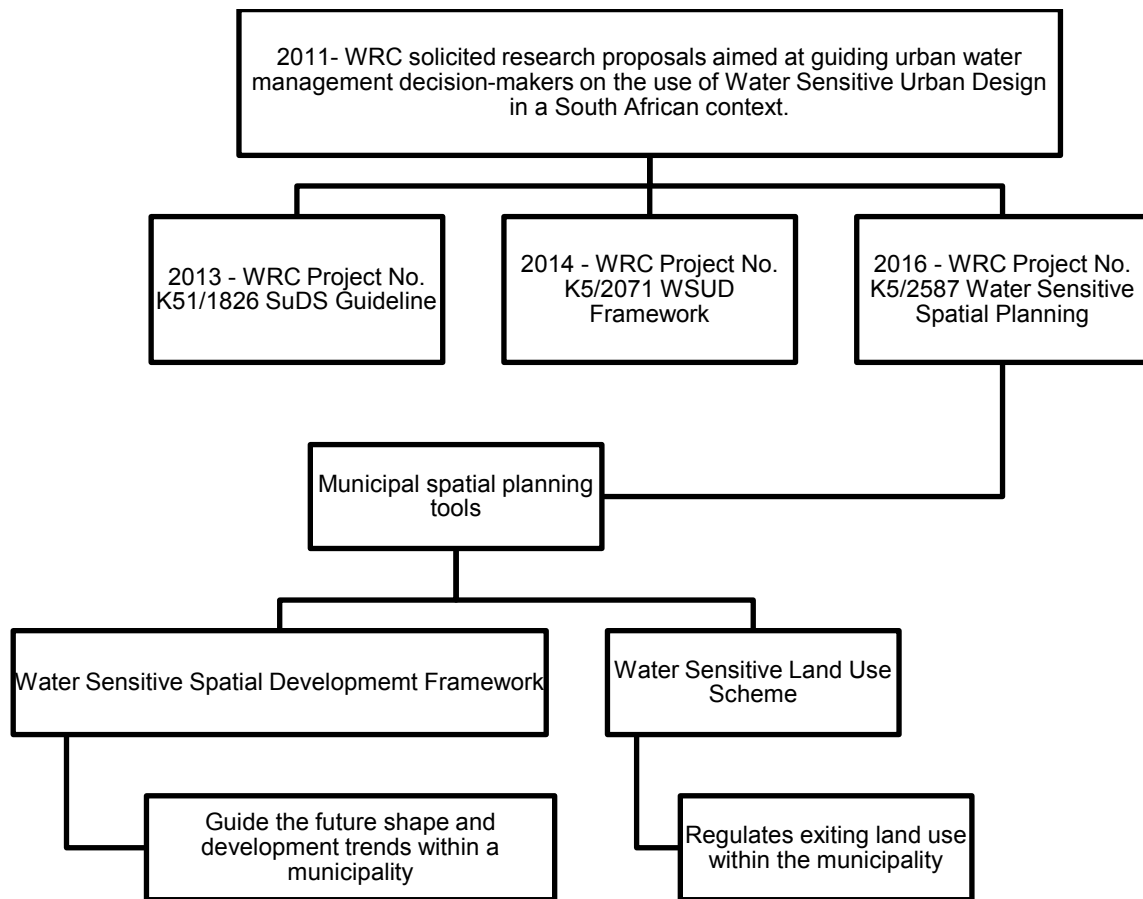


Figure 1-3: Conceptual framework of the study

Source: Own Construction (2018)

1.8 Limitation of the research

While this study acknowledges that spatial planning and land use management also function within a hierarchy of spatial plans, this study deliberately chose to focus only on municipal level spatial planning and land use management as the spatial decisions and land use activities managed through the municipal spatial development framework and the municipal land use scheme has a direct impact on water quantity and quality.

Due to a lack of spatial data, several of the quantitative spatial assessments were limited to urban areas, as not enough detailed spatial data existed in rural areas. Furthermore, the study used Census 2011 data, as the spatial scale of Census 2016 data is limited to municipal boundaries and not on a mappable, subplace spatial scale.

CHAPTER 2 LAND WATER RESOURCE RELATIONSHIP

2.1 Introduction

The philosophical position which underpins the study holds that water is a central component in the Earth's system. Water is indispensable for all life on Earth in its present form and influences virtually every aspect of the planet's life support system (Bengtsson *et al.*, 2014). Hence it is humanity's responsibility to protect it. However, the reality is that freshwater resources and their ecosystem services are being degraded and depleted at alarming rates, despite its pivotal role in supporting life on Earth. With rapidly increasing population figures and urbanisation rates, unsustainable patterns of production and consumption have become the norm. Today, anthropological interference is changing Earth's natural system. It has direct climate implications that affect both water quality and quantity. Dealing with these issues is more urgent than ever before.

By way of introduction to this study, Section 2.2 sets the foundation by reflecting on literature proving that there is a close relationship between land and water resources, collectively known as the natural hydrological cycle. Section 2.3 takes a different view by discussing the impact of anthropologic interferences in Earth's natural system and natural resources availability. In terms of Earth's natural resources availability, Section 2.3.2 focuses on the evolution of water infrastructure brought upon by global urbanisation trends and industrial innovations. Section 2.3 concludes with criticism towards conventional infrastructure systems. Section 2.4 provides information on future water resource-related challenges and observations. This section focusses specifically on certain studies reflecting on global observations, predicted futures and the impact thereof on water resources. Section 2.5 draws a conclusion.

The chapter is structured as follows (see Figure 2-1):

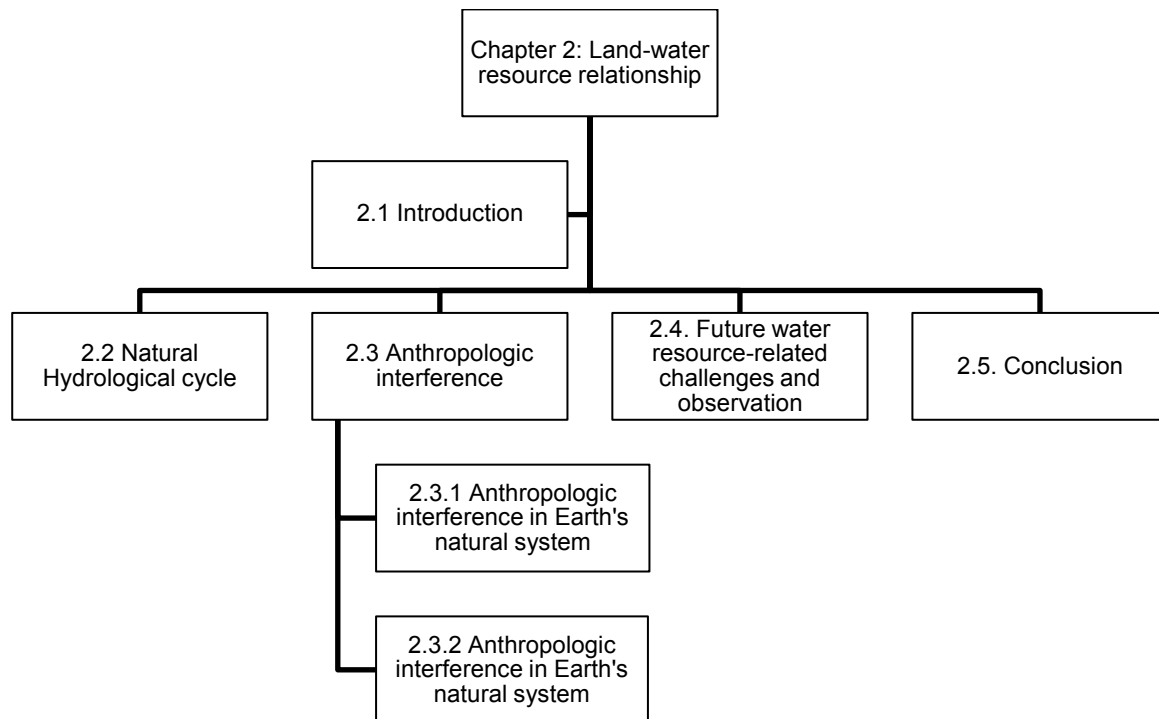


Figure 2-1: Conceptual structure Chapter 2

Source: Own Construction (2018)

2.2 Natural hydrological cycle

Earth's total surface area is approximately 510 million km², roughly divided between 30% (153 million km²) of land and 70% (357 million km²) of water (Coble *et al.*, 1987:102; Weast, 1981:202; Zabel *et al.*, 2014:5). It is evident that Earth is a water-heavy planet, or so it seems. Several decades ago, experimental scientists such as J. Besson (1569), B. Palissy (1580), P. Perrault (1674), E. Mariotte (1686), E. Halley (1687) and SG. Gmelin (1774) made numerous breakthroughs in determining “quantitative estimates of the various components of the water balances”. Dalton (1802) was the first scientist to develop a formula to calculate evaporation from free-water surfaces. It was a significant contribution to the development of water-balance concepts (cited by Nace, 1971:14). Dalton's work was followed by significant methodologic studies of well-known scientists such as A.I Voeikov (1884), Newell (1894), A. Penck (1896), E.A. Geints (1898), W. Ule (1903), P. Schreiber (1904), H. Keller (1906), A. Coutagne (1921), P.S. Kuzin (1934), W. Wundt (1937), L.K Davidov (1953), V.A. Troitskiy (1949), R. Keller (1962), and others (cited by Lvovitch, 1970:408). Remarkable successes in modelling the cycle, or approximate versions thereof, followed through conceptual and empirical models. Davis & De Wiest (1966:460) illustrate the natural hydrological cycle in Figure 2-2, placing emphasis on the sub-surface components that are often neglected as they are somewhat invisible to the human eye.

Figure 2-2 shows a closed-loop system through which water travels, making it a renewable natural resource (Camp & Heath-Camp, 2015:515; Watson, 1993:24; Sarni, 2011:31). “As temperatures rise, heat results in evaporation from land and water resources. As the water vapour rises, it cools and condenses to form clouds. When conditions are appropriate, water in clouds is released as precipitation (rain, hail, snow, or sleet) and falls to the earth’s surface” Davis & De Wiest (1966:460).

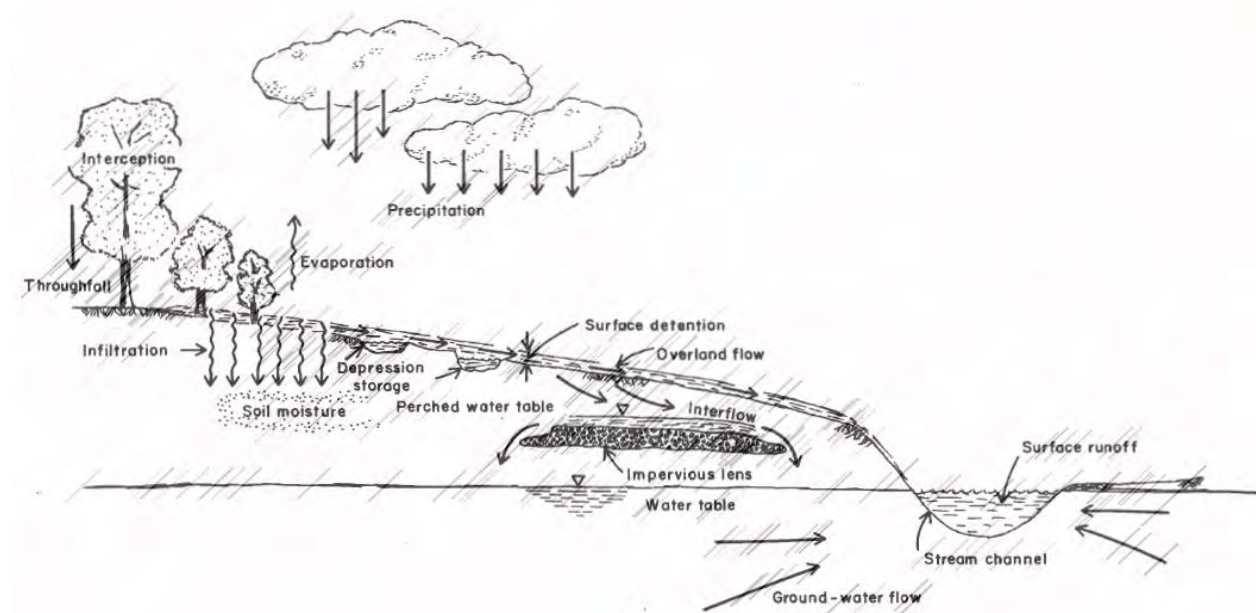


Figure 2-2: Diagrammatic representation of the natural hydrological cycle

Source: Davis & De Wiest (1966:460)

According to Edwards *et al.* (1983:22) “the intercepted moisture stored in the canopy of a tree is the first component of the hydrological cycle to be lost directly back to the atmosphere. The interception of raindrops by canopies/trees reduces soil erosion, which protects surface soils and maintains infiltration, which is the second step of the hydrological cycle. When precipitation falls through the canopy, through-fall infiltrates into the soil and becomes soil moisture or groundwater”. However, this process depends on the infiltration capacity of the soil. Horton (1933), Philip (1969), Hillel (1971) and Morel-Seytoux & Khanji (1974) define the infiltration capacity of soils as the rate at which water can enter the ground. When soil infiltration capacity is low, precipitation will result in surface runoff, which will seep into streams, rivers, wetlands, estuaries and oceans. “If the soil infiltration capacity is high, due to good surface cover, infiltration will lead to aquifer recharge, which takes place in the saturated zone of the subsurface, reaching the water table and becoming groundwater” Wilhelmson & Ramamurthy (2010).

According to Nel (2017:9) “Groundwater may remain underground for hundreds or thousands of years, or flow and discharge as springs, rivers, lakes or to the ocean to continue the cycle”. As water travels through the natural hydrological cycle and interacts with ecological infrastructure such as soil, wetlands, and rivers, it undergoes a series of physical, chemical and biological reactions which purifies water (Hairston & Stribling, 2001:2; CapeNature, 2014). This purification process is an essential factor to the renewability of water resources.

The total volume of water within the hydrological cycle amounts to some 1.4 billion cubic kilometres. According to Gleick (1996:817-823) 96.5% is saline and found in the ocean, and 1.74% is locked away in ice caps, glaciers, and permanent snow. Only a small fraction of 1.7% is groundwater, of which 0.76% is freshwater and 0.94% is saline. According to the US Geological Survey, rivers and lakes are most visible to the human eye and are, consequently most likely to be used for public water supply (Perlman, 2016). Unfortunately, these resources only account for 0.0132% of Earth's total water resources (Gleick, 1996:817-823), hence the saying that less than one percent of freshwater is readily accessible for direct human use (Shiklomanovs, 1993:3-5; DWA, 2013b:2; Mullen, 2012; Perlman, 2016; USGS, 2016; NASA, 2003; van Beek *et al.*, 2011).

The global distribution of precipitation and the availability of water resources in different areas are largely driven by climatic forces and biomes as captured in the Köppen Climate Classification System (Larson & Lohrengel, 2011:120; WWAP, 2017:10). According to Köppen's Climate Classification System (Ibid.), based on a region's relative location to Earth's equator, some regions experience an abundance of precipitation throughout the year (e.g. Climate Zone C and D predominantly found along middle to high latitudes, mostly from 25° to 70° N and S), while others only receive seasonal high precipitation (e.g. Zone A close to the equatorial zone at low latitudes ranging between 15° N and S). Whereas arid and semi-arid regions (Climate Zone B found between 50° N and S, but mainly in the 15° to 30° latitude in both hemispheres) is faced with a continues ordeal of limited and unevenly distributed precipitation throughout the year.

Due to the climate systems' inherent complexity, it remains unclear what controls Climate Zone B and the extent or aridity level of existing dry regions in present-day climates (Levine, 2017). Yet the Hadley circulation has repeatedly been referenced as one of the causes of regional aridity. The Hadley circulation, also referred to as “Hadley cell”, is a global scale tropical zone or atmospheric circulation as illustrated in Figure 2-3 (Thompson, 1975:39; Agnew & Anderson, 1992) (cited by Maliva & Missimer, 2012:25). According to Heffernan (2016:21), “the downward limb of the Hadley cell creates some of the driest deserts on the planet, such as the Kalahari in southern Africa and the Sahara in northern Africa. It is also one of the most common measures of the boundary between the tropics and the drier subtropics”.

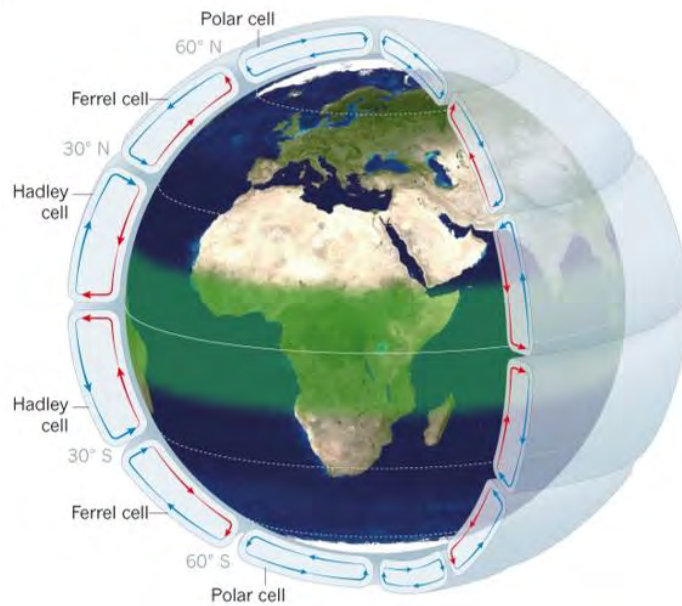


Figure 2-3: Hadley circulation and the expansion of the tropics

Source: Heffernan (2016:21)

Accumulating evidence proves that the tropical zone is expanding its latitude across both hemispheres (Hudson *et al.*, 2006; Fu *et al.*, 2006; Seager *et al.*, 2007; Lu *et al.*, 2009; Birner, 2010; Davis & Rosenlof, 2012; Zhou *et al.*, 2001; Hu *et al.*, 2011; Hu & Fu, 2007). In 2014, Lucas *et al.* (2014) published their research findings proving that the tropic latitude is expanding at around 0.5° to 1.0° per decade, translating to 1.25° to 2.5° per 25 years, or 138 to 277 km. Further research suggests that “this climatic phenomenon is caused by rising global temperatures triggered by an increase in greenhouse gas (GHG) emissions, largely driven by human activities embedded in economic and social needs” (IPCC, 2014:4).

2.3 Anthropologic interferences

According to Wong and Chen (2010), on a global scale the natural hydrological cycle can be considered metaphorically as Earth's “metabolism”, which by definition is a set of chemical reactions that occur in living organisms to maintain life. Unfortunately, the increased occurrence of life on Earth has altered the rate and functionality of Earth's metabolism, making the renewability of water resources increasingly questionable. The following section looks at the impact of anthropologic interferences in Earth's natural system and natural resources availability.

2.3.1 Anthropologic interferences in Earth's natural systems

The origin of noticeable climate change can be traced back to the industrial era when “technological advances in coal mining led to coal having the largest share in primary energy mix” (Zou *et al.*, 2016:1). The industrial era is also notorious for its global impact on urbanisation and rapid land-use and land-cover change. According to Forster *et al.* (2007) a significant increase of approximately 10% between 1800 and 1900, and 27% between 1900 and 2005 in the total volume of CO₂ atmospheric emissions can be mainly attributed to growth in the industrial sector and deforestation or land-cover change.

As GHG is released into the atmosphere, it forms a layer in Earth's atmosphere which prevents natural heat from escaping into space. Simltaneously, concrete surfaces found mostly in urban areas also contribute to increased solar radiation. Combined, they have caused a global increase mean surface temperature with unbalanced effects at local level, as illustrated in Figure 2-4. According to the IPPC (2014), during 1986 and 2005 ocean temperatures increased by 1°C while precipitation across oceanic regions decreased by 10%. A relatively consistent increase of 1.5°C was recorded over most continents, except for regions located within climate zones D and E, which experienced an average temperature increase of up to 4°C. The IPPC (2014) noticed that changes in precipitation over Earth's surface were not uniform.

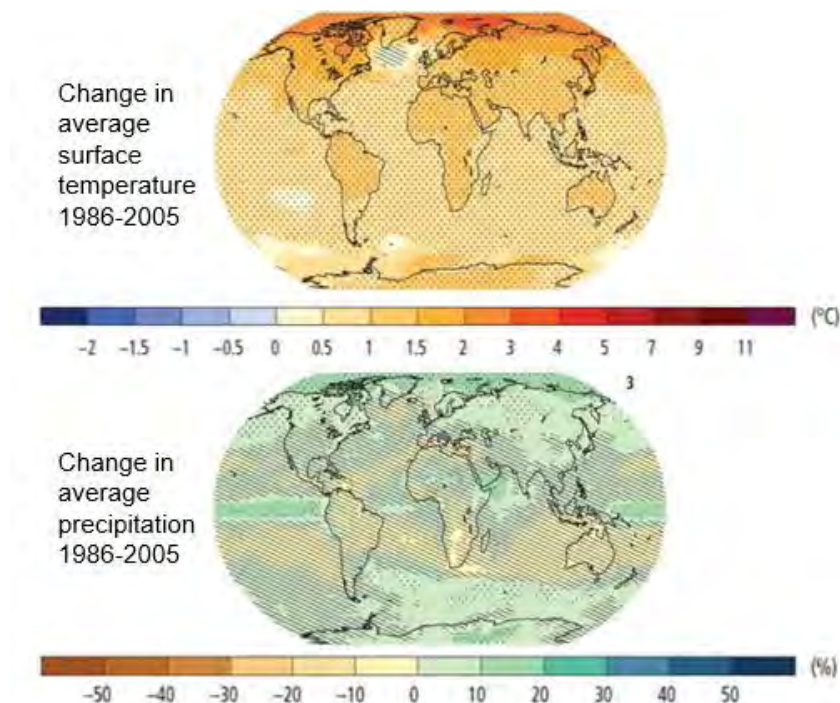


Figure 2-4: IPCC Climate Change Observations 1986–2005

Source: IPCC (2014)

Figure 2-4 illustrates that between 1986 and 2005, precipitation decreased with 10% over Australia, central and southern Africa, as well as the northern regions of South America. Precipitation increased by approximately 10% throughout the western regions of North America, the southern tip of South America, and some regions across North Africa; while a 20% increase in precipitation was recorded over East Africa.

The IPCC also reported that the period between 1983 and 2012 was likely the warmest 30-year period in the last 1400 years (IPCC, 2014:2). These observational records prove that the change in global temperature has a direct impact on spatial and temporal precipitation patterns. These changes will most likely cause decreased precipitation in already water-stressed areas, and increased frequency and longer durations of heat waves (IPCC, 2014:5). Furthermore, the IPCC (Ibid.) also reports that “despite a growing number of climate change mitigation policies, the total anthropogenic GHG emissions caused by, amongst others, land cover change has continued to increase between 1970 to 2010, with larger absolute increases between 2000 and 2010”.

2.3.2 Anthropologic interferences in Earth’s natural resource

In addition to causing global climate change, the industrial era coupled with rapid urbanisation and population growth also led to increased water resource consumption and wastewater production affecting both water quality and quantity.

2.3.2.1 Water supply in the antiquity

Demographers estimate that around the years 8000–7000 BC the world population was between five and six million people (Roser & Oritiz-Ospina, 2018). Archaeological evidence proves that these ancient civilisations selected their settlement location mainly on its proximity to water resources as rivers and springs were tapped into for daily use (Kellett & Jones, 2016:302; Driaux, 2016:43).

At the time, “no one thought about separating drinking water from wastewater until villages become towns. The direct impact of this growth was seen in the water resource quality as the natural purification process was overwhelmed by human interference” (Ashkenazi, 2012). People became ill from drinking polluted water, and the separation of drinking and wastewater made its first appearance as a well, during the Neolithic period, around 5000 BC (Ibid.) when global population figures reached an estimated 17 million (Roser & Oritiz-Ospina, 2018). As urban populations continued to grow, cities needed more water than what a single well could supply. During the Bronze Age (ca. 3200–1100 BC) when the world population increased from 44 million to approximately 115 million, several urban water supply systems began to make their appearance (Angelakis *et al.*, 2012).

According to Mays *et al.* (2007:1) one of the most sophisticated water supply and sewage disposal systems was built in Mohenjo-Daro, a major urban centre of the Indus Civilisation. Jansen (1989:180) explains that “this system supplied water for domestic purposes from more than 700 wells”. Sewerage was disposed of by using an “interconnected network of open effluent drains built of brick masonry, which ran alongside the streets of Mohenjo-Daro” (Ibid.:189).

Between 1000 and 0 BC, some remarkable urban infrastructure networks known as aqueducts were constructed by the Greeks (Koutsoyiannis *et al.*, 2008). “The Romans perfected this system with their extended spring water supplied aqueduct systems” (Mays, 2010). The Romans’ gravity-fed distribution networks brought public water supplies, fed by groundwater sources, to the pinnacle of reliability in the ancient world (Rodà, 2016). During the same period, the Chinese also built a “series of large-scale hydro projects such as the Grand Canal Jing Han” (1 797 km long) and the Zhengguo Aqueduct (300 km in length) providing water for irrigation and domestic uses (Angelakis & Zheng, 2015:456-457; Giovanni *et al.*, 2014:3942). During the Han Dynasty (202 BC–220 AD) urban hydraulic techniques assisted Chang’an City, the capital of the Han Empire, to reach one of the peaks of urban history (Zheng, 2015; Yang, 1989). This urban water system model included primitive but innovative water supply, water storage, rainwater management, and drainage systems.

Throughout the history of urban centres, water supply has been the backbone of each city. While the antique urban water infrastructure systems were influential in the construction of most cities’ water and wastewater systems, these ancient systems struggled to supply sufficient amounts of water to growing communities.

2.3.2.2 “Modern” urban water cycle

According to Roser & Oritiz-Ospina (2018), over the course of 0 AD and 1700 the world population grew to approximately 415 million, which increased the direct domestic demand for water resources significantly. Furthermore, the transition from hand production methods to machines and steam engines, pivotal to the industrial revolution, required improved efficiency in water power (Zou *et al.*, 2016:1). The industrial era caused urbanisation rates to inflate as predominantly agrarian rural societies moved to urban areas, as the “factory system” lured large numbers of rural workers to the cities in search of work in factories.

According to Roser & Oritiz-Ospina (2018), between 1700 and 1800 the “world population increased by 0.04% annually”. Although 0.04% is considered low, the world population reached its first billion in 1803. By this time, 3% of the global population lived in urban areas (Barken, 2012).

The combined effects of population growth, industrialisation and urbanisation radically increased the demand for water and cities were forced to secure water supplies from alternative resources. In addressing this increased resource demand, engineers pursued a more sophisticated and reliable solution for water distribution and treatment.

The use of traditional high-quality groundwater was replaced with a more abundant but lower-quality surface water source; which cities were able to exploit through water distribution networks. These networks consisted of dams, reservoirs, pumps and extensive pipelines that temporarily divert a portion of the water for human use. This infrastructure network made it possible for municipalities to supply larger quantities of water to growing towns and cities. However, due to increased usage, water quality began to suffer greatly as used, untreated water made its way back into the natural water cycle, either via direct discharge from municipal sewage (untreated) and factories, or indirectly through evaporation from irrigated fields. Planners, architects and engineers of the time recognised not only the health risks, but also aesthetic challenges related to the existing system.

During the early 1900s, “global population figures reached 1.65 billion” (Roser & Oritiz-Ospina, 2018), “14% of whom lived in urban areas” (Barken, 2012). Unsanitary conditions brought on by heavy industrialisation and urbanisation soon led to the development of large-scale water purification systems. The design objective of these treatment systems was to mimic the “metabolism” effects of the natural hydrological cycle – “treating polluted water resources to an appropriate water quality standard before discharging it into natural waterways” (Angelakis & Snyder, 2015:4888). Today it is referred to as a modern urban water distribution network, designed to operate within a centralised closed-piped system where water, wastewater and stormwater are separated into isolated sectors of management.

Figure 2-5 is a simplified schematic illustration of a typical modern water distribution system, which starts by “extracting (1) raw water from dams, rivers and sometimes groundwater resources. Raw water is then (2) pumped through a (3) conveyance network to a (4) centralised water treatment plant. After treatment, water is distributed to (5) reservoirs through distribution pipelines. Inspired by the Aqueduct rationale (see Section 2.3.2.1), reservoirs are usually located on higher ground, if topography permits it, as the system relies on pressure fed by kinetic energy. If the topography does not permit it, additional energy is used to (6) distribute water to customers through internal pipe networks” (Van Zyl, 2014:11).

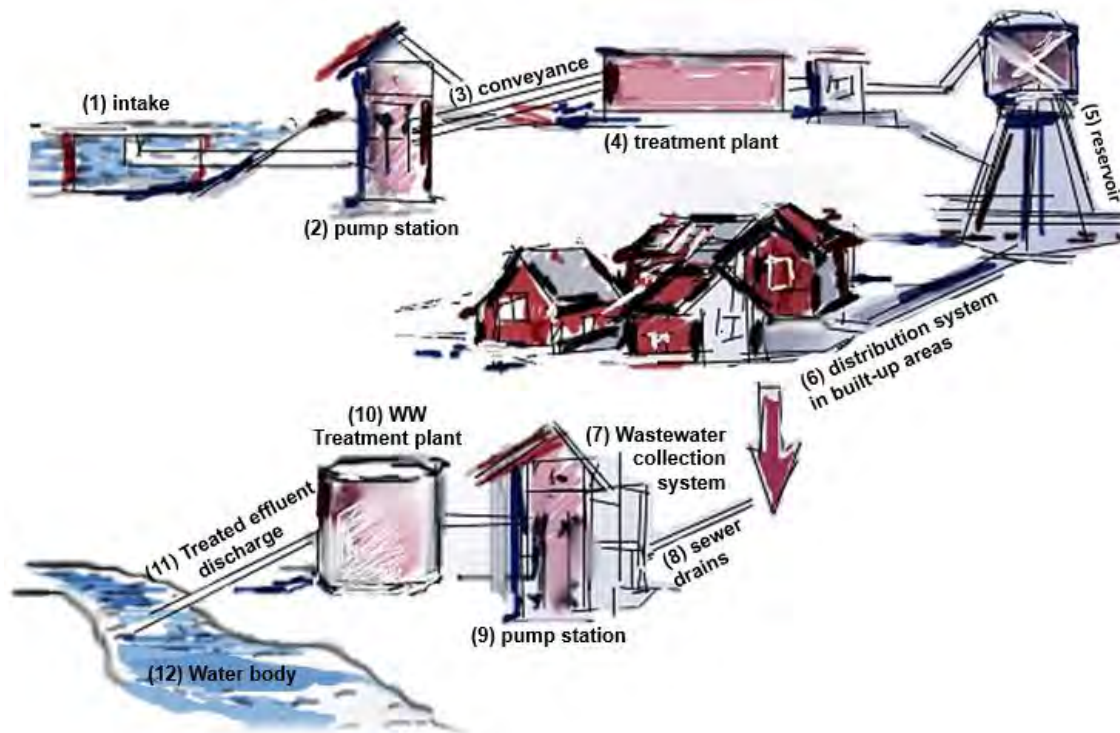


Figure 2-5: Schematic urban water distribution network

Source: Own creation (2017)

“Once consumed, greywater and sewerage are (7) collected and passed through a (8) network of sewer drains to (9) pump stations which pump the raw sewerage to a (10) centralised wastewater treatment plant, where wastewater is treated. Treated effluent is then (11) discharged back into the (12) natural water body where it once again forms part of the natural hydrological cycle” (Ibid.). With this modern urban water distribution network in place, developers of the early 1900s were able to identify land for development and economic activities far beyond previously limited built-up areas. In some way it could be argued that this network of modern water infrastructure facilitated rapid transformation and occupation of land inside and outside of densely populated urban areas. However, increased built-up areas and impermeable surfaces also caused increased runoff, which called for a more sophisticated method of treatment.

At first glance, “cities and stormwater are not mutually compatible as the space required for natural drainage systems such as rivers, streams, wetlands, and ponds restrict urban development” (SWITCH, 2011). Secondly, unlike within undeveloped areas (see Section 2.2), once natural vegetation becomes impervious, the infiltration capacity of soils reduces drastically, resulting in increased runoff volumes, peak discharges, and less groundwater recharge (Saad *et al.*, 2013:1254; Korgaonkar *et al.*, 2014:3; Makepeace *et al.*, 1995; Leopold, 1968; Rose & Peters, 2001).

According to Verburg *et al.* (2011:974), Chapin *et al.* (2000:234) and Lambin *et al.* (2001:262) impervious surfaces can lead to alterations in the biogeochemical cycles, climate, ecosystems processes, and ecosystem resilience, thereby changing the nature of ecosystem services provision and human dependencies. Increased runoff volumes and rates can lead to flooding and damage to buildings and other man-made infrastructure. Since the early urban era, the focus of stormwater management was to direct large volumes of water, that were unable to infiltrate into the soil, out of the urban environment as fast as possible (EPA, 2005:15). This was, and still is today, achieved through concrete drainage and discharge channels collectively termed conventional stormwater infrastructure. There are two predominant methods of dealing with urban stormwater – either through a combined or a separated system.

The combined stormwater system conveys both sewage and rainwater in a single pipe to the Wastewater Treatment Works (WWTW), where it is treated before its released back into the natural environment. Separated systems distribute stormwater runoff and wastewater through two separate pipeline networks. While combined stormwater management systems treat stormwater before discharge, separate stormwater management systems discharge polluted stormwater back to receiving water bodies with little or no treatment at all. According to Erskine *et al.* (2011:5) this combined system is mostly used in older developed countries such as Europe and the United States, whereas the separate system is commonly found in newer, developing countries (Erskine *et al.*, 2011:5). The US Environmental Protection Agency (EPA) (1999) noted that combined sewers are increasingly becoming unable to cope with the hydraulic loading. As a result, the incidence of untreated effluent being spilled directly into the environment is growing, with serious ecological implications and public health risks. While the separate system provides for a higher level of resource protection by separating underground sewer lines into sewer and stormwater pipes, the construction of such systems is almost unaffordable for many cities (Erskine *et al.*, 2011:6).

In terms of the qualitative impact on water, in both systems, stormwater is highly susceptible to non-point sources pollution (EPA, 1999). The most common non-point source pollution is caused by “accelerated erosion due to human activities such as deforestation, poor agricultural practices, road construction, and landscaping” (Ibid.). These activities cause high levels of sedimentation and turbidity that limit the penetration of sunlight into the water and physically disrupt the hydraulic characteristics of the channel. Furthermore, fertilisers, animal waste, organic matter, and septic tanks produced excess nitrogen (N), nitrates (NO₃), Ammonia (NH₃), and phosphorus (PO₄) in the air and water, causing high levels of nutrient pollution. Other pollutants commonly found in stormwater include “organic matter, pathogens, hydrocarbons, metals, toxic chemicals, and solids such as debris and rubbish” (Ibid.).

While conventional water, wastewater, and stormwater infrastructure has been the sought-after solution for many decades, more recently it has become frowned upon and criticised for being fragmented, lacking flexibility, and being energy intensive. Often the implemented measures are not cost effective or sustainable in the long term (see Table 2-1) (SWITCH, 2011).

Table 2-1: Criticism towards conventional water infrastructure systems

Fragmentation:	“The various elements of the urban water system are often operated in isolation. Such fragmented approach can result in technical choices that are based on the benefits to an individual part of the system but may neglect the impacts caused elsewhere”.
Short-term solutions:	“Water management both in developed and developing countries often focus on today’s problems, opting for short-term solutions despite the risk that the implemented measures are not cost effective or sustainable in the long term”.
Lack of flexibility:	“Conventional water infrastructure and management tend to be inflexible to changing circumstances. Water supply, wastewater treatment and stormwater drainage systems are constructed to match fixed capacities and when these are exceeded, problems occur”.
Energy intensive:	“Conventional water distribution and treatment infrastructure is energy intensive. Power cuts and rapid increases in fuel costs can disrupt services. Intensive energy uses also result in high levels of CO ₂ emissions at a time when many urban environments are trying to reduce their carbon footprint”.

Source: SWITCH (2011)

Bahl & Bird (2016) add that “most local governments in developing countries lack the managerial and technical ability to maintain current infrastructure”. Furthermore, low-income countries would rather prioritise spending on capital works to reach a larger segment of the population than on maintenance. The downside to this approach is that existing infrastructure is not replaced, nor is it upgraded. This places tremendous strain on the physical, hydrological, and water quality integrity of water, wastewater and stormwater distribution systems (National Research Council, 2006:7-10). These allegations are supported by several observations to be discussed in Section 2.4.

2.4 Future water resource-related challenges and observations

In 2007, the International Water Management Institute (IWMI) conducted a major study, 'A Comprehensive Assessment of Water Management in Agriculture', which analysed “past water development efforts from the perspective of costs, benefits, and impact” (IWMI, 2007). The assessment considered societies' need for economic and rural development, increased food security, agricultural development, health, and environmental conservation, and the threat of ecosystem degradation (Ibid., 2007:vi).

Figure 2-6 illustrates on a global scale the level of water scarcity experienced in 2007. The report exposed society to the concept of water scarcity and defined three levels:

- i) physical water scarcity;
- ii) approaching water scarcity; and
- iii) economic water scarcity.

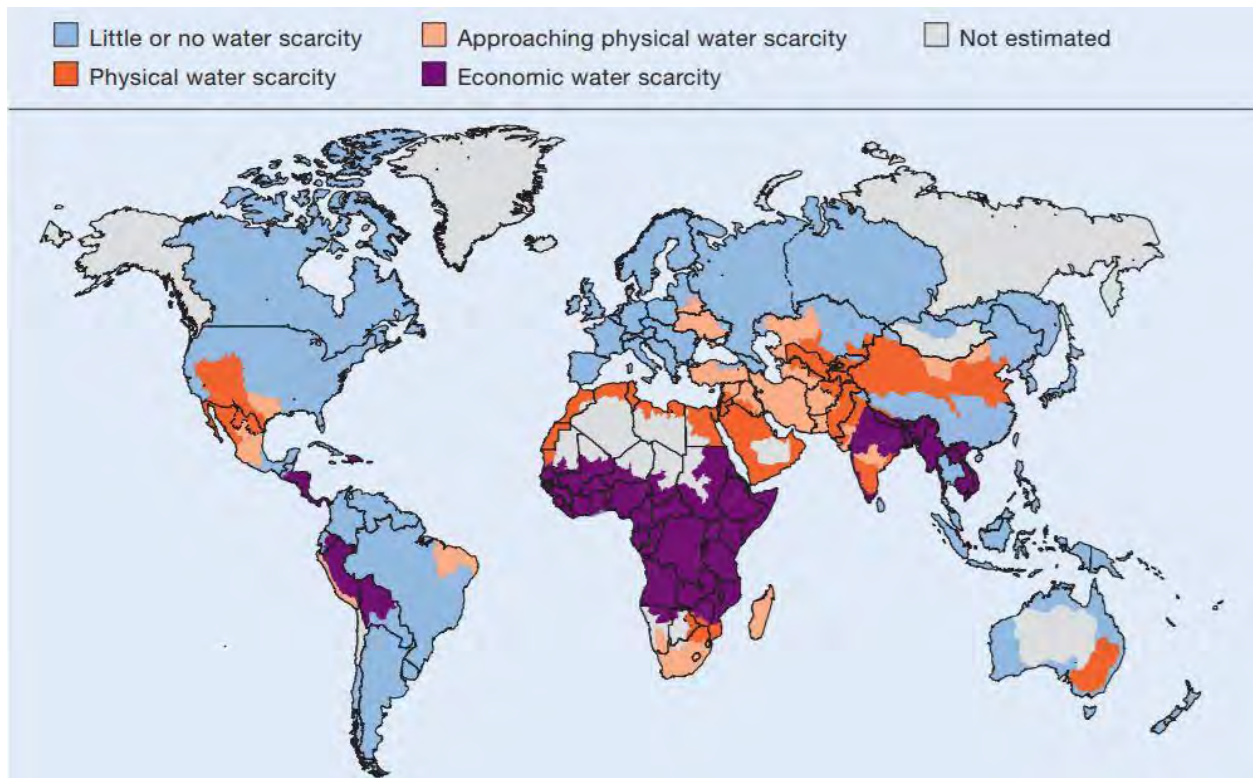


Figure 2-6: Areas of physical and economic water scarcity

Source: IWMI (2007:11)

The report defines economic water scarcity as “a situation experienced in countries or regions where water resources are abundant relative to water use, as less than 25% of water from rivers is withdrawn for human purposes, but malnutrition still exists” (IWMI, 2007:11).

This is mainly caused by “a lack of human capacity and financial investment in water infrastructure comprising the physical integrity of the infrastructure network and its ability to distribute water from rivers and aquifers to where it is needed” (Ibid.). According to the assessment, around 1.6 billion people, many of whom reside in Sub-Saharan Africa, faced economic water shortages in 2007 (Ibid.). While economic water scarcity can be prevented, naturally arid regions frequently suffer from physical water scarcity as water is not abundant enough to meet all demands, such as those required by an ecosystem to function effectively.

According to the IWMI (2007:12) “physical water scarcity is experienced when more than 75% of river flows are allocated to agriculture, industries or domestic purposes (accounting for recycling of return flows). Countries can also approach physical water scarcity when more than 60% of river flows are allocated. These basins will soon experience physical water scarcity”.

The assessment revealed that in 2007, about 1.2 billion people, or almost one-fifth of the world’s population, lived in areas of physical scarcity, while 500 million people are approaching this situation (IWMI, 2007). The report emphasised the need for “better water management in agriculture, otherwise the Millennium Development Goals (MDG) for poverty, hunger, and a sustainable environment will not be met” (IWMI, 2007:10).

2.4.1 Issues with water distribution networks and WWTW

Between 2000 and 2010, several new monitoring programmes were launched. Of particular importance to this study is the “WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation (JMP)” (WHO/UNICEF, 2010). This monitoring programme reported on the status of access to safe water and sanitation services and the progress made towards the MDG targets. The report highlighted that “in 2008, approximately 2.6 billion people still did not have access to improved sanitation services and that the MDG target for sanitation will be missed by over a billion people” (WHO/UNICEF, 2010:6). The WHO/UNICEF predicted that by 2015 there would be 2.7 billion people without access to basic sanitation (see Figure 2-7) (WHO/UNICEF, 2010:8).

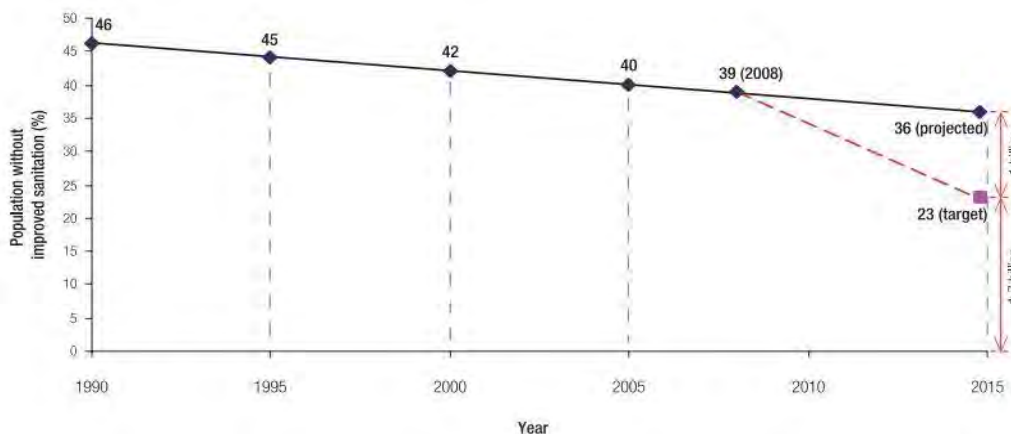


Figure 2-7: Sanitation: world is projected to miss the MDG target

Source: WHO/UNICEF (2010:8)

As for access to safe drinking water, the WHO/UNICEF JMP reported that “in 2008, 884 million people still did not have access to improved drinking-water sources” (WHO/UNICEF, 2010:7). However, 2015 predictions did indicate that the MGD target to half the proportion of the population without sustainable access to safe drinking water will be exceeded.

Unfortunately, “672 million people would still have no access to safe drinking water by 2015” (see Figure 2-8) (WHO/UNICEF, 2010:9).

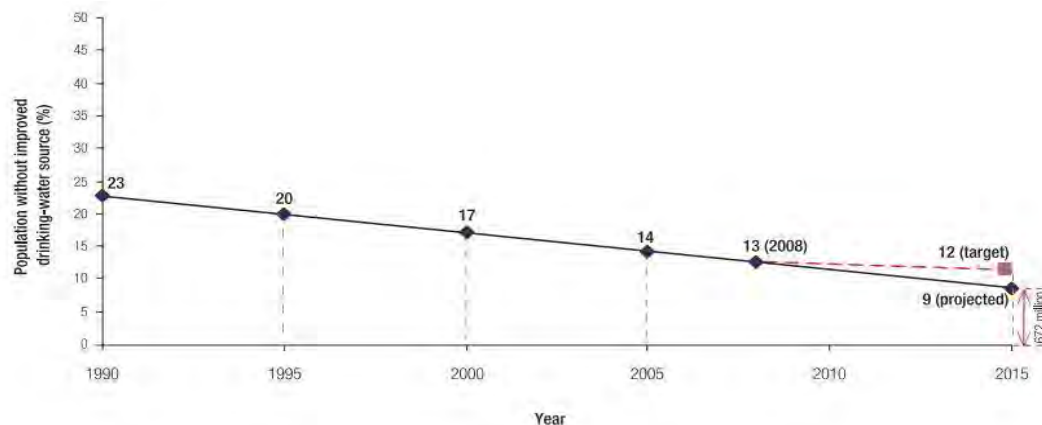


Figure 2-8: Drinking water: world is projected to miss the MDG target

Source: WHO/UNICEF (2010:9)

It could be argued that failing to meet the MDG targets to halve the proportion of the population without sanitation in mostly developing countries, can in some way be blamed on the fact that conventional infrastructure lacks flexibility, is energy intensive, fragmented and a short-term solution contradicting long-term sustainability, as note in Table 2-1.

2.4.2 Projected impact of urbanisation and population growth on water resource quantity and quality

In 2010, the global population figure reached 7 billion people, equivalent to a 4.4 times population increase over the last century (Roser & Oritiz-Ospina, 2018). With the substantial increase in population figures, society also entered the urban century as more than half of the world’s population resided in urban areas. Hobbs *et al.* (2006) described these urban centres as “novel ecosystems characterised by fragmented and disturbed environments, high densities of fabricated structures and impervious surfaces with strong heat-retaining abilities, and elevated levels of usage of some resources.” The latter part of Hobb’s description, “...elevated levels of usage...” was found to be true in many large cities, including “Bangkok (Thailand), Nanjing (China), Porto Alegre (Brazil), Montevideo (Uruguay), Johannesburg (South Africa), Los Angeles and Phoenix (United States), with recorded consumption patterns ranging between ten and twenty times the World Health Organization’s (WHO) daily recommended amount” (UN-Habitat, 2013:70). On a global scale, the Food and Agriculture Organization (FAO) reported that water withdrawal increased by 7.3 times over the last century – increasing 1.7 times faster than the world population growth (FAO, 2016a).

The combined effects of increased water withdrawal coupled with a lack of access to proper sanitation facilities, also caused higher volumes of untreated wastewater to be discharged into the environment. According to the United Nations fourth report on World Water Development published in 2012, “80% of agricultural, industrial and municipal wastewater is discharged into the environment without any form of treatment, while only 20% of globally produced wastewater receives proper treatment” (UNESCO, 2012). Global trends indicate that this is mainly attributed to rate at which wastewater is generated exceeding the rate at which conventional wastewater treatments plant can purify polluted water, ultimately resulting in decreased water quality.

2.4.3 Future water resource uncertainties

To shed light on future uncertainties, several institutions focused on predicting future realities. Addressing population and urbanisation trends first, the UN DESA (2015:2) predicted that the global population figure will reach 9.7 billion by 2050, with most of the growth deemed to take place in Africa due to the continent's annual growth rate of 2.55%. It accounts for more than 1.3 billion people alone (UN DESA, 2015:3). Of the 9.7 billion, over 70% or 6.4 billion people are predicted to reside in urban areas. According to Bradley *et al.* (2002), Falkenmark & Lindh (1974) and McDonald *et al.* (2011) the predicted population growth will increase total water demand for adequate municipal, industrial and agricultural supply.

Alexandratos and Bruinsma (2012) add that “by 2050, agriculture will need to produce 60% more food globally, and 100% more in developing countries”. In addition, the “urbanisation trends will mostly likely create rising income levels, which will change food habits towards richer and more varied diets...not only to increasing consumption of staples cereals, but also a shift in consumption patterns away from cereal crop towards livestock and fish products and high-value crops...”, which in order to produce them will require far more water resources (IWMI, 2007:8).

It is also anticipated that “for urban areas to accommodate this growth, urban space which currently occupies 3% of global land cover, will need to double in developed countries and expand by 326% in developing countries” (Angel *et al.*, 2011). Intermediate cities, “those with populations of between 20 000 and 200 000 – will have to make room for a population growth of up to 5% annually” (Ibid.). This growth in population and the need for space will trigger rapid land cover – widely recognized as the major driver of habitat and biodiversity loss.

Following Section 2.3.1, the IPCC (2014) states that continues urbanisation will also contribute to higher surface temperatures. Uneven increase in average surface temperature ranging between 4°C and 7°C can be expected. Uneven distribution of precipitation will be even more severe as some areas within Australia and southern Africa will experience a 30% decrease in precipitation (see Figure 2-9).

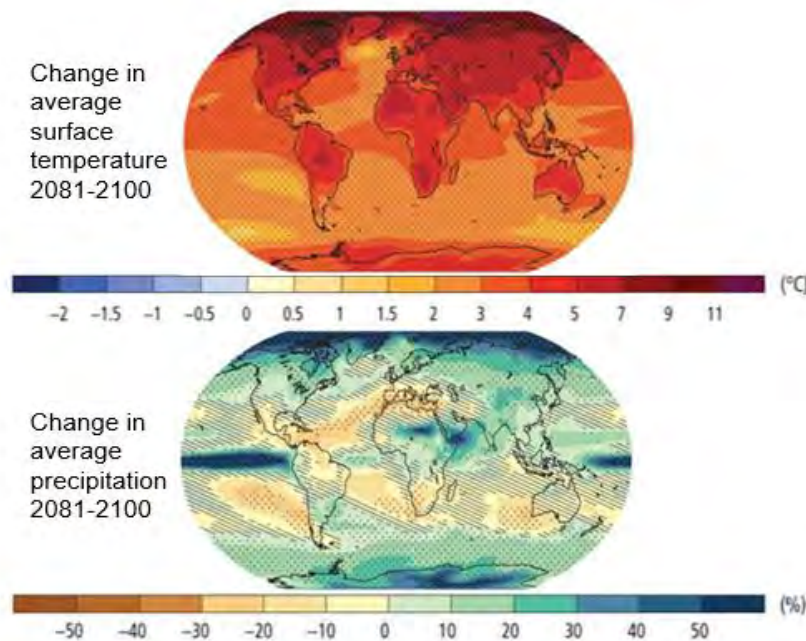


Figure 2-9: IPCC Climate Change Predictions 2081–2100

Source: IPCC (2014)

The IPCC's climate projections provide evidence that globally freshwater resources are most vulnerable to climate change – potentially causing wide-ranging consequences for human societies and ecosystems (Vitousek, 1994; Millennium Ecosystem Assessment, 2005; Jetz *et al.*, 2007). Urban areas have also been earmarked as areas that will pose increased risks for people, assets, economies, and ecosystems. These are mainly related to the effects of heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise, and storm surges (IPCC, 2014:16).

According to Satterthwaite (2007:4) the scale of the risk posed by urban areas is determined by, amongst others, the quality of housing and infrastructure in a city, and the extent to which urban planning and land-use management has successfully ensured risk reduction measures. Thus, it is anticipated that the impact of climate change will be felt most intensely by poor communities residing in southern Africa and dependent on natural resource for direct use; and living in informal settlements often located outside of the land use management plan (Hardoy *et al.*, 2001:448).

2.5 Conclusion

The interdependent relationship between land and water resources is inevitable as the one depends on the other to remain ecologically stable. Although society has made remarkable successes in understanding this close relationship, development trends of the 20th and 21st century have caused irreversible effects on both water quality and quantity. The evolution of water infrastructure systems enabled cities to provide high volumes of better-quality water over thousands of kilometres. This has not only caused high water consumption patterns and wastewater generation to become the norm in many cities, including Johannesburg (South Africa), but also facilitated the rapid expansion of non-permeable surfaces. As noted in Section 2.3.2, these surfaces not only fragment landscapes but also alters biogeochemical cycles, climate, ecosystems processes, and ecosystem resilience. Chapter 2 elaborates on land use decisions having a water quality and quantity impact.

The Southern African region is particularly vulnerable to future uncertainties as countries within this region are already constrained by arid climates. According to future climate prediction this region “will most likely become hyper-arid, adding additional strain to the already limited resource base” (Bates, 2008). The southern African region will also experience rapid population growth and urbanisation in the coming years. This growth will add strain to the region’s natural resources base as well as its physical infrastructure, making physical and economic water scarcity the most likely predicted future. Furthermore, communities residing in large parts of Southern Africa are predominantly poor, located in informal settlements, and in most cases outside of any formal land use management plan, will be affected worst by climate change (IPCC, 2014).

Based on the information presented in this chapter, the remainder of this study will focus on South Africa specifically – in an attempt to guide future spatial planning and land use management practices towards water sensitive outcomes.

CHAPTER 3 HYDROSOCIAL CONTRACT

3.1 Introduction

The notion of a hydrosocial contract was first introduced by Turton & Ohlsson (1999) at the 9th Stockholm Water Symposium. According to Warner (2000:3-4) a country's hydrosocial contract shows conceptual development, which forms the basis on which institutional arrangements are subsequently built. Turton & Meissner (2015:1) state that "...by understanding this concept in a more profound manner, it is anticipated that water resource managers will be better equipped to deal with issues that are emerging from rapidly changing environments". While Chapter 2 established the close relationship between land and water resources, this chapter argues that the hydrosocial contract should also be included as part of broader urban and regional planning approaches, especially since spatial planning (also in South Africa) has played a major part in achieving national governments' socio-economic and political agenda.

The hydrosocial history of South Africa's water resource is closely connected to the settlement of the land, for various reasons. The purpose of this chapter is to explain South Africa's spatial development trends and water resources management history in a concise manner. It also aims to highlight when and how international development trends related to land and water resources planning and management have affected South Africa. The purpose is to illustrate the meaning of certain developments and related events in relationship to South Africa's hydrosocial contract. This chapter is structured chronologically.

As such, Section 3.2 starts with an overview of South Africa's early era of industrialisation and urbanisation, the latter which increased significantly after the Second Anglo-Boer War when many Afrikaners were left impoverished and thousands left their farms to settle in cities. This era also saw radical new departures in urban and regional planning, vested in the internationally acclaimed concept of formal institutional settlement building and local apartheid legislation. Regarding water resources, industrial development of the post-war era had a profound impact on the availability of water resources. Section 3.2.3 provides a brief discussion on the Department of Water Affairs' early approach to water resource management, which was primarily based on the approach to increase supply to meet demand despite the concerns raised by the Commission of Inquiry for Water Matters.

Section 3.3 considers international calls for sustainable development, which have also resulted in the birth of a green generation. Section 3.4 focuses on South Africa's road to democracy from 1990 onwards. During this period, government restructuring took place and several new policies and legislation impacting on both land and water resources were adopted.

Section 3.5 focuses on South Africa's key socio-economic strategies adopted from 2000 onwards. This section also provides a review on the key national socio-economic strategies which mainly focused on rural development and economic growth. The review highlights that a lack of spatial guidance often resulted in failure of implementation.

Section 3.6 provides a review of South Africa long-term socio-economic development roadmap, led by the country's National Development Plan. This section also provides a brief review of all second-generation policies and plans as well as international obligations towards sustainable development adopted from 2010 onwards. Section 3.7 draws a conclusion.

This chapter is structured as follows (see Figure 3-1):

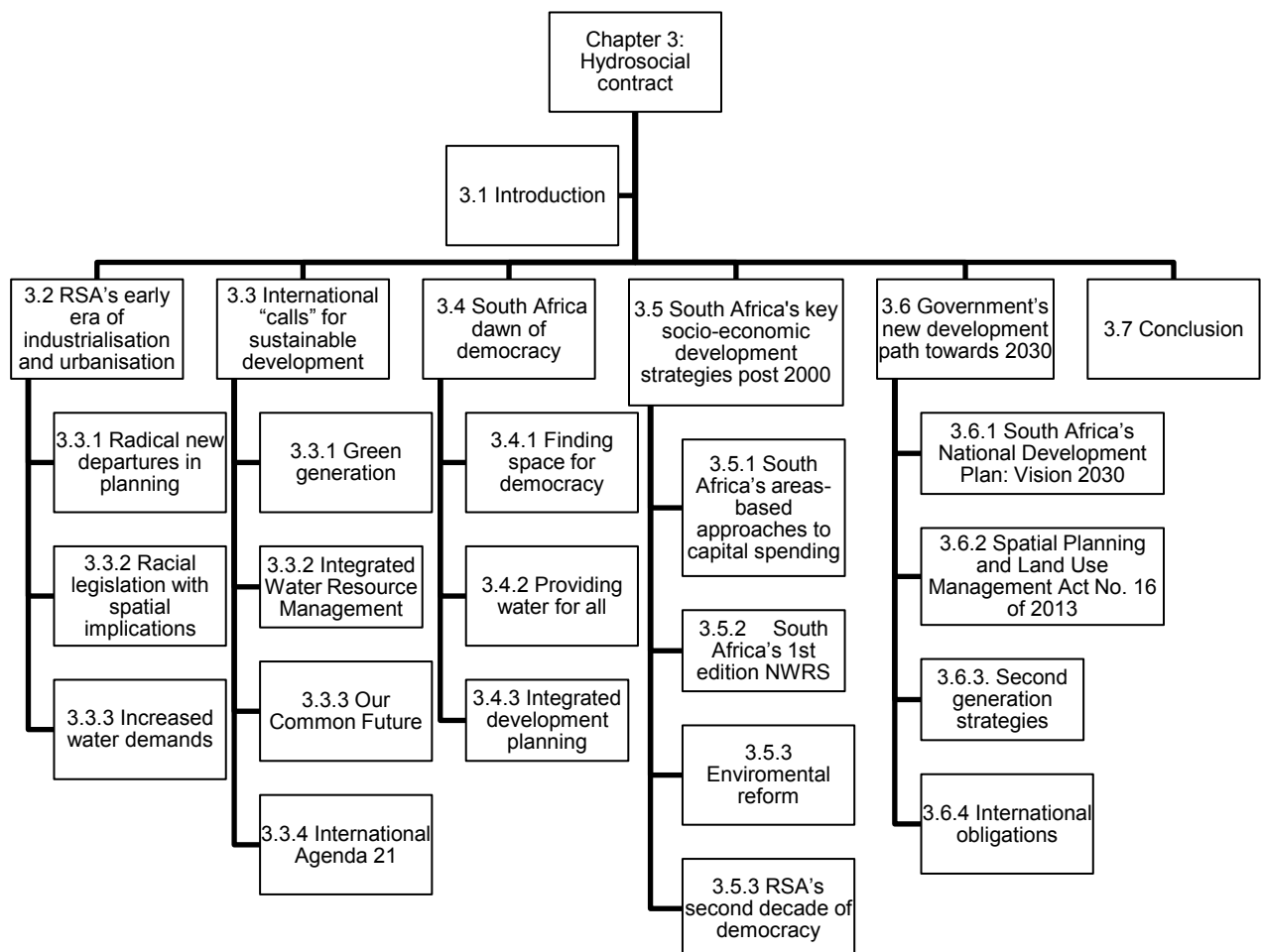


Figure 3-1: Conceptual structure Chapter 3

Source: Own Construction (2018)

3.2 South Africa's early era of industrialisation and urbanisation 1700 - 1990

Official colonisation of South Africa started somewhere between 1650 and 1700 when the initial halfway station, established by the *Vereenigde Oostindische Compagnie* (VOC), became a colony (Pearson, 2012:99-138; Cameron & Spies, 1986:53; Ross, 1999:21). According to Giliomee & Mbenga (2007:42) the colonisers “brought with them Western cultures and western ‘intellectual baggage’”, “like the Roman-Dutch Law, the reformed religion and capitalism” (Ross, 1999:21).

In early 1800, a British Colony was formally established, introducing the freehold tenure of land and, with that, the riparian principle of English-American law. According to Rowston (2011:21), “this had a profound effect on the State’s control of water resources as all natural rights that were attached to land and specifically land alongside rivers belonged to the owner”. This meant that the owner of the property had exclusive and in-perpetuity right to access water in the rivers (Ibid.). However, “disputes over water rights became prominent, and a Special Water Court was established to determine new water allocation” (Tewari, 2008:699). The Special Water Court also assigned the responsibility of providing water supply and sanitation services to local councils for their respective towns and villages.

The discovery of diamonds, and more importantly gold, during the late 1800s soon led to a ‘mineral revolution’ which stimulated rapid industrialisation and urbanisation (Oosthuizen, 2000). The mineral revolution also brought along European technicians, capital and a railroad system deep into the country's interior (Thompson & Lamar, 1981:23). According to Turton *et al.* (2004:39) “...this technical skill, capital, and infrastructure were much needed prerequisites for the development of irrigated agriculture later in the nineteenth century.”

At the time, the country was divided between the British Empire, states formed by Afrikaner settlers, and various native African states. Britain’s desire to control the entire region soon led to the Second Anglo-Boer War, lasting between 1899 and 1902 (Turok, 2012:6; Pakenham, 1986:200; Van Zyl, 1987:333; Davenport & Saunders, 2000:223). The official ending of the Anglo-Boer War took place on 31 May 1902, which led to the signing of the Treaty of Vereeniging (Turton *et al.*, 2004:54). The British authorities ensured that land owners would regain power over their farms. However, many Afrikaners were left impoverished and thousands left their farms to settle in cities.

In 1910, the Act of Union was signed, and the country gained independence (Republic of South Africa, 1909). During this period, “authorities wanted to recast urban society through social and civil engineering, which required new government structures” (Giliomee & Mbenga, 2007:49).

This led to the establishment of municipalities in terms of the Transvaal Ordinance Establishing Municipalities No 58 of 1903 (Republic of South Africa, 1903). Government also adopted a new water law in 1912, the Irrigation and Conservation of Waters Act 8 of 1912, which aimed to deal with the endemic dry and low rainfall conditions of the time (Thompson *et al.*, 2001:12; Republic of South Africa, 1912). Even though the Act superseded all previous colonial water laws, the riparian principle remained a central feature and the discriminatory practice of unequal allocation of water resources perpetuated (Uys, 2008:v; Mackenzie, 2009:443).

3.2.1 Radical new departures in planning

One year later, the first key piece of apartheid legislation, the Native Land Act of 1913, was passed by the Union (Magubane, 1996:148; South Africa, 1913). Act 27 of 1913 had a major impact on the way in which urban and rural areas are structured today, as it set aside approximately 7.3% of the country's land area as reserves to accommodate the 'Native' population (South Africa, 1913). The Act also created a system of land tenure, meaning that land under "communal" tenure was vested in African Chiefs and prohibited native people from owning land outside of the reserves. According to Rowston (2011:25) the "combined effects of the riparian system, by which access to water resources was linked to land ownership, and the severe restriction on land ownership by the majority black population, access to water was in favour of the minority white population". Act No. 27 of 1913 was followed by the passing of the Natives Urban Areas Act No 21 of 1923, which "forced blacks into outlying townships or locations and gave local authorities the power to demarcate and establish African locations on the outskirts of white urban and industrial areas" (Turok, 2012:7; South Africa, 1913).

During the Great Depression of 1930, even though the riparian principle was still in force and favourable for agricultural uses, a significant number of Afrikaner farmers moved to towns as several regions faced serious drought conditions (Davenport, 1989; Turton *et al.*, 2004:50). The migration of a vast number of people called for radical new departures in planning. The internationally acclaimed concept of formal institutional settlement building as announced by Le Corbusier and the *Congress International du Architecture Moderne* (CIAM) gained local interest in the late 1930s. The concept highlighted the importance of spatial planning and the regulation of land and introduced a 'new' linear urban model with high-rise residential structures and large proportions of green landscapes (see: Figure 3-2) (Tyrwhitt, 1933).

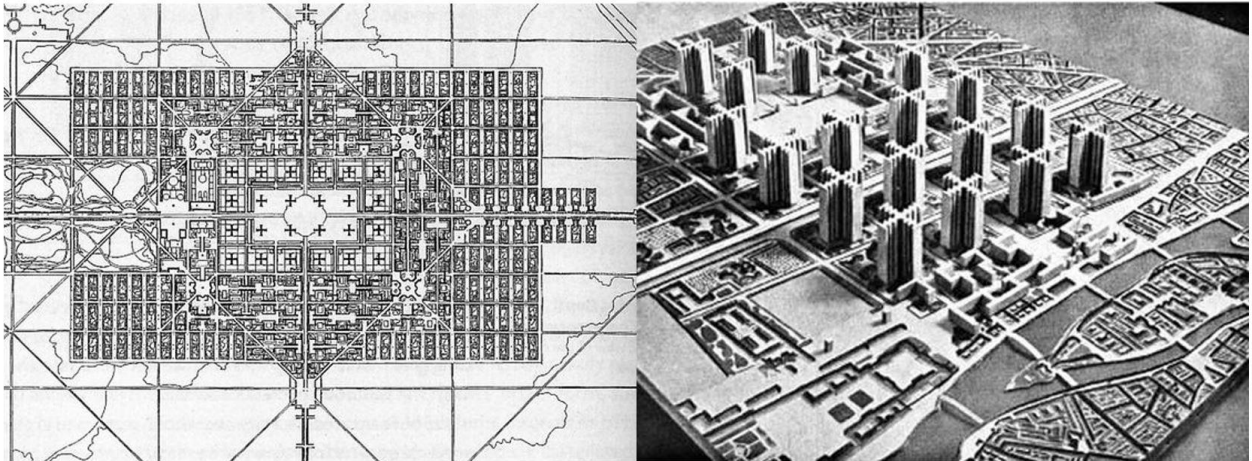


Figure 3-2: Le Corbusier's Functional City model

Source: Tyrwhitt (1933)

South Africa's government was enthusiastic of the modernist movement and established the Department of Physical and Regional Planning to conduct national and regional planning and zoning to ensure the enforcement of strict spatial planning rules and land use regulations (Union of South Africa, 1944; Herbert, 1983). The first Provincial Town Planning and Settlement Establishment Ordinance was also implemented, granting local authorities' greater control over land use, building size and housing density (National Development and Planning Commission, 1999:4). According to Parnell and Mabin (1995:55) "it was a coincidence that town planning in South Africa emerged at a time when the modern movement in architecture and planning was at a high". The modernistic movement, which was based on the theory of comprehensive segregation of land use, clearly lent itself to apartheid spatial planning in South African cities. It soon became clear that the agencies who administered town planning had "racial zoning" on their agenda.

3.2.2 Racial legislation with spatial implications

In 1936, the Native Trust and Land Act (Act 18 of 1936) increased the "native reserve" land area from "7.3% to almost 13% of the total land area of the Union" (South Africa, 1936). More specifically, the act prohibited any ownership and/or purchase of land by natives outside the stipulated reserves, formalising the separation of urban White and rural Black areas.

What became visible was a spatial pattern of segregated cities facilitated through the apartheid city model. This model was deliberately designed to separate races and classes into distinct segments of the city (SACN, 2004:25). Figure 3-3 illustrates the design structure of a typical apartheid city model, which informed many urban master plans at the time.

The spatial structure of the apartheid city model, pushed poor and especially poor black residents to the margins of the city. It left them with no other option but to live in sprawling, squalid dormitory townships of undifferentiated ‘matchbox’ houses (Ibid.). These areas were poorly serviced with infrastructure and urban amenities, while white residents had access to large, well laid out, well serviced, and tree-lined suburbs, conveniently located close to employment and major urban facilities (Ibid.).

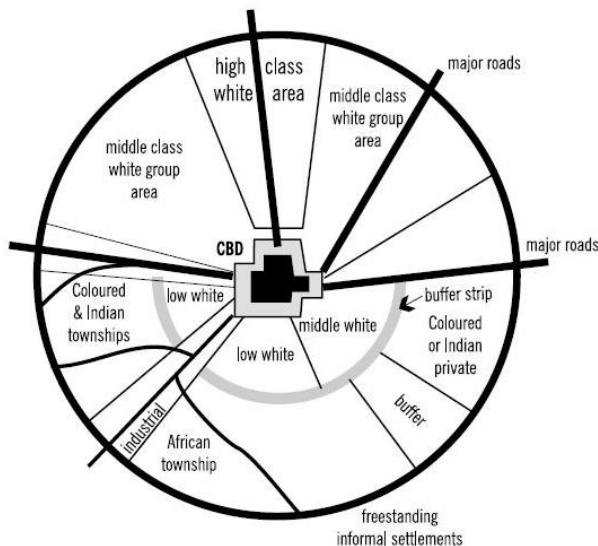


Figure 3-3: Apartheid City Model

Source: SACN (2004:25)

Between 1950 and 1980, the so-called “grand apartheid” took place. This phase of development in South Africa saw intense spatial and racial segregation as twenty-two (22) additional Apartheid laws were passed. The 1967 Physical Planning and Utilization of Resources Act was used to control African urbanisation by placing limitations on the extent of proclaimed industrial land in the main urban areas (O’Malley, 2016). It also called for the development of guide plans, which embodied elements of forward planning (Van Wyk, 2012:41). However, according to Van Wyk (Ibid.) guide plans were only to cover urban areas, excluding rural homelands and black settlements from spatial planning.

3.2.3 Increased water demands

In terms of water resources, industrial development in the post-war era, combined with population growth and improving living standards – specificity of the white Afrikaner –, placed increasing demands on the country’s limited water resources. In 1956 a new water law, Water Act No. 54 of 1956, was enacted, replacing the 1912 Irrigation and Conservation of Water Act (South Africa, 1956).

Even though the riparian principle still remained, the act introduced two new innovative administrative devices – ‘normal’ and ‘surplus’ flow – which allowed the Water Court to authorise the use of ‘surplus’ flow on non-riparian land for urban or industrial use (Ibid.).

Still, the growing demand for water resources remained unsatisfied. The Department of Water Affairs solution was to build more dams and to develop inter-basin transfer (Van Vuuren, 2009). These transfers would convey water from one catchment with excess supplies to catchments with a shortage in supplies (DWA, 1988:2). The National Department of Water Affairs found water transfers to be a financially acceptable approach to water resource management (Showers, 1996:1). However, little consideration was given to the long-term environmental consequences of dam construction and water transfers. King *et al.* (2011:12) explain that, at the time, the impact of dam construction and water transfers on donor aquatic ecosystems was not understood by management and not voiced effectively by the scientific community. As a result, it was not factored into water resource planning in any structured way, if at all.

With regards to water resource management, an Inter-departmental Committee of the Soil Conservation Board was assigned to investigate geographic areas known for their high water supply (Government of South Africa, 1961). By the end of the investigation, the inter-departmental committee identified, hand-mapped and categorised 109 mountain catchments areas – see Figure 3-4 (Nel *et al.*, 2013:10).



Figure 3-4: 109 Hand-mapped mountain catchment areas

Source: Nel *et al.* (2013:10)

During the same period, the Commission of Inquiry for Water Matters was appointed to investigate and make recommendations on all aspects of water provision and utilisation (Government of South Africa, 1970). The commission gave special attention to, amongst others, determining the volume of surface and groundwater resource availability and future potential. It compiled a long-term national master plan for coordinated development, conservation and control of water resources; made recommendations for the systematic development of potential water sources; and identified water-saving and re-use methods to be applied immediately (Ibid.:xii-xiii). The Commission published its findings and recommendations in 1970, declaring that "...unless essential steps are taken to plan the exploitation and augmentation of our water resources, to conserve and re-use our available supplies, and to manage and control our resources in the most efficient manner, serious shortages will be suffered somewhere before the close of the century" (Ibid.:3). The commission recommended that water saving in urban areas could be achieved through improved water use methods, elimination of leakage, pressure regulation at distribution points, instalment of individual metering, and reduction in the size of urban plots (Ibid.:6). These recommendations became known as water demand management (WDM) (Turton *et al.*, 2004:68).

By the mid-80s, South Africa experienced one of the worst droughts ever (DWA, 1988). Many experts argue that the effect of the drought was aggravated by the local water resource management philosophy of increasing supply to meet demand. The Department embarked on developing numerous policies aimed at bringing change and stability within the sector. The Department identified the following issues, amongst others, to be addressed:

- "various principles of the existing water law derived from European countries, where climates, cultures and hydrology were very different to that of South Africa;
- the relatedness between water resources quality and quantity management was not fully addressed;
- while the Minister had the power to restrict water usage during drought, he was unable to provide measures to regulate and ensure WCDM at all times;
- there was a need for a well-structured water tariff policy or pricing structure to give effect to the economic value of water; and
- there was an urgent need to regard rivers as integrated systems and to control them in a catchment-orientated way" (Ibid.).

To the Department's disappointment, the ruling party rejected the above policy proposals.

To aggravate the effects of the extreme drought which lasted until 1987, South Africa also experienced the worst domestic turmoil and racial unrest the country had ever experienced. According to Turton *et al.* (2004:77-78) the unrest grew out of the context of economic hardship due to recession, international sanctions and drought.

Many townships became militant and ungovernable, and residents boycotted their rent and service charges, which created a financial crisis for many municipalities (Barber & Barratt, 1990:304; Geldenhuys, 1990:333). “Infrastructure began to collapse, and physical and social conditions deteriorated” (Turok, 2012:11). This era of development “facilitated a deep class-based segregation which still characterises South African cities and towns” (COGTA, 2016:22).

3.3 International “calls” for sustainable development 1950 - 1990

Roughly during 1950 and 1970 several international conferences, including the UN’s Scientific Conference on the Conservation and Utilization of Resources in 1949; the World Population Conference in 1954 and the Biosphere Conference in 1968, were held to raise awareness on the growing anthropological impact on ecosystems and the biophysical environment (UNSCCUR, 1949; Peter & Cox, 1954; UNESCO, 1993:22).

Unfortunately, the mid-20th century was faced with a development crisis as global population figures reached an estimated 3 billion in the early 1960s, approximately 30% of whom lived in urban areas (Roser & Oritiz-Ospina, 2018). According to Roser & Oritiz-Ospina (Ibid.) the world population growth rate peaked in 1962 at 2.1%, adding one billion people in 33 years. Accommodating this growth led to the rapid appearance of modernistic New Towns in suburban areas, which relied on resource-intensive technologies, architecture and urban planning models creating intense carbon economies (Kirkby *et al.*, 1999:2-6). Despite international efforts to raise awareness on sustainable development, increased interference of anthropological activities and worsening socio-economic conditions, especially in the global south, triggered noticeable environmental discourse (Quental *et al.*, 2009:18; Birkeland, 2012:168).

3.3.1 Green generation

According to Roser & Oritiz-Ospina (2018) the global population figure reached its 4th billion in less than 15 years since 1962. During this era, society also entered a new phase of development supported by technological advances in communication and information technologies. According to Black (2012), these scientific advances led to the birth of the “green generation” in the global West as new knowledge on the causes of environmental degradation became known. Two principal schools of thought came from Western civilisations. One “blamed greed and the relentless pursuit of economic growth”; while the other “blamed population growth” (UNEP, 2002:2), encapsulated in the most famous study of the time, the “Club of Rome model” (Meadows *et al.*, 1972:11). Even though the model was highly criticised, it “publicised for the first time in history the concept of outer limits, emphasising the idea that development could be limited by the finite size of the Earth’s resources” (Meadows *et al.*, 1972:86).

Between 1971 and 1972, the UN and the IUCN directed the signing of several multilateral environmental agreements, including the Convention on Wetlands (1971); the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (1972); and the United Nations Conference on the Human Environment (UNCHE) (1972), also known as the Stockholm Conference (Ramsar Convention Secretariat, 2016:8). The latter is often credited as a fundamental catalyst in building international awareness of Earth's environmental problems.

During the Stockholm Conference, UN Secretary-General Maurice Strong raised his concerns on the rapid growth of cities, which he described as “cancerous”, as governments around the world failed to provide proper housing, causing rapid expansion of slums and squatter settlements, incompatible to the concept of human dignity (Changeways International, 2009). Strong also emphasised his concerns of ocean and water pollution as “...poisonous new residues of progress, accumulate in mounting quantities in water throughout the world causing death and distress” (Ibid.). Strong's statements raised global awareness about pollution. So much so, that the 1970s faced a realisation that environmental problems were due to a complex interrelationship between humankind, global resources, and the social and physical environments (Turner, 1988).

In combating these concerns, the Stockholm Declaration was adopted. It emphasised the “need for the development and implementation of environmental policies, strategies, plans and actions as a basis for future development” (Bayulken & Huisinigh, 2015:13). According to Long (2000) the Stockholm Declaration was the “first body of ‘soft law’ adopted as part of international environmental affairs”. The UNCHE also led to the founding of the United Nations Environment Programme (UNEP) which organised a symposium on Patterns of Resource Use, Environment and Development strategies in Cocoyoc, Mexico, 1974 (UNEP, 1974). The symposium debated the social and economic causes of environmental degradation, which led to the signing of the Cocoyoc Declaration (Ibid.).

The Cocoyoc Declaration changed the attitudes of leading environmental thinkers as it pursued the concept of ‘eco development.’ However, “terminology on what was meant with the concept was limited at the time” (Quental, *et al.*, 2009:20). The Cocoyoc Declaration was followed by the signing of the Vancouver Declaration in 1976, which emanated from the UN Conference on Human Settlements (1976) in Canada, also referred to as HABITAT I (United Nations, 1976). The Vancouver Declaration stated that unacceptable human settlement circumstances were likely to be aggravated by inequitable economic growth and uncontrolled urbanisation, unless positive and concrete action was taken at national and international levels (United Nations, 1976:2).

Not long after HABITAT I, Richard Register, founding president of Urban Ecology (1975), introduced a concept of 'eco-city' development. Inspired by the early writings of Carson (1962); Olgyay (1963); McHarg (1969); Banham (1969) cited by Lehmann (2010:2), Register (1987) defined eco cities as "cities built according to the principle of living within the means of the environment; i.e., with its population and the artefact produced and used, remaining within the ecological carrying capacity of the city's bioregion". Register's vision for an eco-city, as seen in Figure 3-5 was based upon an integral neighbourhood design consisting of diversity and higher densities in city centres, the use of narrow streets and increased garden spaces (Ibid.).



Figure 3-5: Ecocity Berkeley

Source: Register (1987)

Register also proposed that eco-cities should be built with "...multi-level solar greenhouses, rooftop gardens, fruit trees in the streets, restored creeks, and with other elements of biology extended into and through the city" (Register, 1987:27). Eco-cities had to be compact, as Register (1987:19-20) wrote, "...if we don't want to steal the fossil fuels from our children... if we want to leave them with a legacy of vital cities and healthy environment, we need to build cities in a far more compact manner that is prevalent today". According to De Jong *et al.* (2015:33) "the eco-city concept was rooted concurrently in the environmental sciences and in the humanities oriented deep ecology movement, proclaiming a return to a life-style in harmony with nature".

3.3.2 Integrated Water Resource Management (IWRM)

Water resource management also reached a turning point in 1977 as the United Nations held the first International Conference on Water (United Nations, 1977). At this conference, member countries agreed that there was a need for, amongst others, integrated water and land-use planning (Section 49) to be “implemented through national legislation and policies to ensure co-ordination of activities and services (Section 94)” (United Nations, 1977:17-110). The report made recommendations on new and improved methods of water resources assessment; water use and efficiency; environment, health and pollution control; policy, planning and management, as well as regional and international co-operation (Ibid.). According to Biswas (2004) the term “integrate” dominated thirty times throughout the conference report. Yet, institutions of the time were found ill-equipped to give effect to the concept (Ibid.). Nevertheless, members agreed that IWRM should be the future of water resources management (Medema *et al.*, 2008).

However, the concept of IWRM went into obscurity up until 1992 (Biswas, 2004:248) during the International Conference on Water and the Environment, where experts saw the emerging global water resources picture as critical (United Nations, 1992). Emanating from this conference was the Dublin Statement on Water and Sanitation, which provided guiding principles to reverse the unsustainable trends of overconsumption, pollution, droughts, and floods (Ibid.). The Dublin Statement re-affirmed the need for an holistic approach to water resources management by linking social and economic development with the protection of natural ecosystems. The statement emphasised that effective management linked land and water uses across the whole of a catchment area (Ibid.). To alter the concerning trajectory of conventional water management, the Dublin Statement proposed that “national and local government revisit their recycling strategies, reassess water charges or tariffs, implement discharge controls, and not accept residual contamination of land and water as a reasonable trade-off brought on by industrial growth” (United Nations, 1992; Biswas, 2004:248).

3.3.3 Our Common Future

Efforts to raise awareness on global environmental issues continued into the 1980s, as the first global declaration was signed as part of the World Conservation Strategy (WCS) (IUCN, 1980). According to Harding (2006:231) the WCS was first to introduce the term “sustainable” in relation to human use of the biosphere and to stress the interdependence of conservation and development. It also recognized that “in addressing environmental problems, national governments had to undertake their own national long-term conservation strategies aimed at combating land degradation, habitat conversion and loss, deforestation, water pollution, and poverty” (IUCN, 1980).

In 1987, the Brundtland Commission released a report, 'Our Common Future', which gave fame to the catchphrase "sustainable development" defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). The report addressed "a full spectrum of development, economic and environmental issues, population, peace and security, and social justice within and amongst generations" (Quental & Lourenco, 2012:361-362). It also expressed concern that the rate of change was outstripping the ability of scientific disciplines and our current capabilities to assess and advise (Ibid.).

3.3.4 International Agenda 21

In June 1992, Agenda 21 was adopted as part of the Rio Declaration on Environment and Development, (United Nations, 1997). Agenda 21 was seen as a blueprint plan designed to mainstream principles of sustainable development into planning processes to guide both environmental and urban development into the 21st century. The principles promoted concepts such as the centrality of human beings to the concerns of sustainable development and the importance of the environment for current and future generations, and its equal footing with development. The conference proposed that the principles should be implemented on local level through policies, plans and programmes of which the aim should be to achieve transformation towards sustainable development (Ibid.). Lastly, it requested members of states to put in place adequate legislative instruments to address environmental issues (Dodds *et al.*, 2012:2).

3.4 South Africa's dawn of democracy 1990 - 2000

A series of national and international events finally led to the unbanning of the African National Congress (ANC), the release of Nelson Mandela and the repeal of several apartheid legislations, in particular the Group Areas and Natives Land Act (Turok, 2012:11). According to Turton (2004:82) the repeal led to a ballooning of the urban population, as blacks from the rural areas came to the towns and cities in search of a better life. They swelled the numbers of the informal settlements and back-yard shacks. It also led to increasing competition for the scarce jobs in the urban areas (Barber & Barratt, 1990:336; Ross, 1999:185). Nonetheless, the South African government succeeded in dramatically changing global perceptions towards the country and international sanctions were lifted. However, South Africa was still characterised by "deep glaring differences in quality of life, large variations in economic activities in different parts of the country, considerable differences in access to services and quality of life and a huge public debt" (Oranje & Merrifield, 2010:35).

The United Nations Conference on Environment and Development (UNCED) had a profound impact on South Africa as local members of the African National Congress (ANC – South African political party) attended as observers of the national liberation movements, which soon led to the drafting of the ANC's Reconstruction and Development Programme (RDP) (Rowlston & Schreiner, 2011:50). The RDP proposed a number of development targets which included the redistribution of land to landless people, building more than one million houses, and providing all households with a clean, safe supply of 20-30 litres per capita per day within 200 meters and adequate/safe sanitation facility per site (Mandela, 1994).

In 1993, South Africa adopted a new Interim Constitution (Act 200 of 1993), which contained 34 constitutional principles applicable to all citizens; stipulated a new government structure; and redefined the country's four provinces and ten 'independent' and 'self-governing' Bantustans into nine provinces (South Africa, 1993). In 1997, the Interim Constitution was replaced by a new supreme law, the Constitution of the Republic of South Africa Act 108 of 1996, which stated that everyone had the right to an environment protected for the benefit of present and future generations (section 24(b)); had access to adequate housing (section 26(1)); and had access to water (section 27(1)(b)) (South Africa, 1996a). Through the Constitution a new government structure was adopted, described as three spheres rather than tiers of government, that is, national, provincial, and local government (Ibid.).

The Constitution granted national and provincial government the power to implement reasonable laws and other measures within its available resources to achieve land, water and related reform as contemplated by the Bill of Rights (Section 25(8)) (section 27(2)). Local government was recognised as the sphere to ensure the provision of services to communities in a sustainable and efficient manner (South Africa, 1996a: Ch.7 S.152). In terms of schedule 4 and 5 of the Constitution, both matters of municipal planning and water and sanitation services were assigned to local government.

Between 1995 and 2000, South Africa's newly elected government was intent on demonstrating its commitment to addressing the past service imbalances as promised by the ANC's RDP policy framework (Rowlston & Schreiner, 2011:50). The redistribution of land, providing housing and access to sufficient water and basic sanitation services for all became a central theme for government.

3.4.1 Finding space for reconciliation

During the time in which South Africa's new government came into power, many homelands were overpopulated, and living conditions did not reflect the vision of democracy.

Government was under pressure to provide land for residential purposes in urban areas, which according to Oosthuizen (2000:103) could only be achieved by either filling up open space in large cities or by expanding the city borders into adjacent rural areas. The latter was found favourable due to the vast areas of land required to accommodate the large-scale, single detached dwelling units as defined by low-income housing schemes (South Africa, 1995).

Parliament promulgated a new act, the Development Facilitation Act No. 67 of 1995 (DFA) in September 1995, which provided administrative preference for RDP housing projects on land outside of proclaimed urban areas (South Africa, 1995). The act was also seen as an interim measure to bridge the gap between the old apartheid era planning laws and a new planning system (South Africa, 1995). However, the DFA did not wipe the slate clean, with the result that national and provincial laws relating to land use planning promulgated before 1994 were still in existence.

Even though the DFA echoed the principles of Agenda 21 of integrated planning, optimal use of existing resources and the promotion of sustainable development (South Africa, 1995), the ambitious programme to eradicate backlogs on the urban periphery gave little consideration to the fact that single-use, low-density development patterns tended to consume significant amounts of land per capita and generated larger per capita infrastructure installation and maintenance costs (UN-Habitat, 2013).

As for the economy, government announced its preference for a new liberal economic policy in 1996, shifting away from a basic-needs RDP orientated economy (Davenport & Saunders, 2000:570; Peet, 2002:54). As such, the Growth, Employment and Redistribution (GEAR) policy was adopted. GEAR aimed to rebuild the economy and to attain a growth rate of 6% per annum through orthodox budgeting, tight control on inflation, and the creation of 400 000 new jobs by the year 2000 (South Africa, 1996b:1). GEAR highlighted the importance of agricultural development and associated land reform programmes for improving long-term prospects for employment and income generation in the rural economy. It also recognised water and sanitation projects as priority projects in rural communities as they would contribute to major poverty relief (South Africa, 1996b:16). However, at the time, the country was in desperate need of generating new financial resources for the construction of new infrastructure for services delivery.

3.4.2 Providing water for all

Regarding water services, an estimated 14 million people across the country lacked access to adequate water supply services, while some 21 million – half the country's population – were without adequate sanitation (Stats SA, 1998).

Backlog in access to services was most prominent in Black rural areas which could, in part, have been caused by the previous system which did not provide for one dedicated department taking responsibility for water supply and sanitation services (DWAF, 2004a:4). Nevertheless, Government adopted a White Paper on Water and Sanitation in 1994, which extended the mandate of existing water boards to assist the DWAF in the extension or rehabilitation of existing rural supply networks (DWAF, 1994) (DWAF, 2004a:5).

In December 1997, the Water Services Act No 108 of 1997 commenced, providing a new institutional framework for the delivery of water supply and sanitation services (South Africa, 1997a). The Water Services Act confirmed the Constitution's long-term goal that local government would take responsibility for providing and sustaining water and sanitation services within their area of jurisdiction (Ibid.). The Act accordingly defined Local Government as Water Services Authorities (WSA), to take the lead in water services decision-making and planning processes by preparing a five-year Water Services Development Plan (WSDP), which integrated technical, social, institutional, financial, and environmental planning (Ibid.:20-22).

The Water Services Act also required the Minister to set national standards and norms for basic water services (Section 9(1)) and standards for water services tariffs (Section 10(1)) (Ibid.:16-18). The DWAF published regulations pertaining to Section 9(1) in June 2001, which introduced the concept of "Free Basic Service (FBS), which is a prescribed minimum standard of services necessary for the reliable supply of water of a sufficient quantity and quality to households, including informal households, in order to support life and personal hygiene, free of charge". Regulation 509 defined the minimum standard for basic sanitation as "...a toilet which is safe, reliable, environmentally sound..." and the minimum standard for basic water supply "...as a minimum quantity of potable water of 25 litres per person per day or 6 kilolitres per household per month (i) at a minimum flow rate of not less than 10 litres per minute (ii) within 200 meters of a household" (DWAF, 2001:2).

The DWAF recognised that the provision of water supply and sanitation services was an activity separate from the overall management of water resources. Yet, it still had to be undertaken in a manner consistent with the broader goals of water resources management as contained in the National Water Act No. 36 of 1998.

While the National Water Act only came into effect in December 1999, the act shifted emphasis from supply management to demand management as an approach to water resource management. The act sought to conserve the nation's water resources through an Integrated Water Resources Management (IWRM) approach, a philosophy and concept that were at the time distilled through an array of key international engagements, declarations and documents.

The act declared national government the public trustee of the nation's water resources, which also repealed all previous riparian laws (South Africa, 1998a:15). In terms of water resource management, the act mandated the Minister to develop and adopt a National Water Resource Strategy (NWRS) (Ibid.:17); declare and establish Water Management Areas (WMA) and Catchment Management Agencies (Ibid.:18-76); and implement resource directed measures (Ibid.:22-30). The latter had to provide for the effective protection of ecosystems necessary to sustain the quantity and quality of water resources to fulfil basic human needs (Rowlston, 2011:28).

Unlike previous water laws, the National Water Act sets clear principles that water resource management cannot be divorced from its border environment (Rowlston & Schreiner, 2011:74), and should also give effect to the National Environmental Management Act No. 107 of 1998, promoting conservation and sustainable utilisation of natural resources (South Africa, 1998b).

Between the Constitution, the Development Facilitation Act, Water Services Act, National Water Act and the National Environmental Management Act No 107 of 1998 (NEMA), an entirely new institutional framework for land, water, and environmental resource planning and management had to be adapted by national, provincial and local government spheres. Adhering to the various mandates such as developing national strategies and plans, and publishing regulations mostly only took place several years into the new millennium.

3.4.3 Integrated development planning

By 2000, local government (South Africa) was still unable to give effect to its constitutional mandate of municipal planning as the abolition of the fragmented South African state and the demarcation of municipal boundaries created confusion regarding the powers and authority of municipalities. "In some areas, municipalities have never practised proper planning functions and have never had any proper planning instruments" (South Africa, 2001). Literature points to the fact that during the transition period from apartheid to democracy, and in the restructuring of local government, limited integrated development planning took place (Dewar, 1998; Asmal, 2000; Donaldson & Marais, 2002).

To overcome this development trend, Parliament promulgated the Municipal Systems Act No. 32 of 2000, which introduced the concept of integrated development planning to assist municipalities in prioritising effective and efficient services delivery (South Africa, 2000). As part of the integrated development planning process, section 23 of the Act required local government to adopt a single, inclusive and strategic plan, referred to as an Integrated Development Plan (IDP) (South Africa, 2000).

Regarding water services, the Water Services Act Section 12(1)(a) and Section 15(5) require that the WSDP is to be prepared as part of the IDP. Regarding spatial planning and land use management, Section 26(e) established a Spatial Development Framework (SDF) as a core component of the IDP (South Africa, 2000).

The content of an SDF was generally unclear to planners, and so the Minister for Provincial and Local Government gazetted regulations that fleshed out the minimum requirements of a municipal SDF (DPLG, 2001). In essence, GRN.796 required municipal SDFs to indicate desired patterns of land use; address spatial reconstruction; provide strategic guidance in respect of the location and nature of development within the municipality; set out basic guidelines for a land use management system; include a capital investment framework; contain a strategic assessment of the environmental impact of the spatial development framework; and provide for a visual representation of the desired spatial form which includes (amongst others) an indication of where public and private land development and infrastructure investment should take place; and an urban edge (DPLG, 2001:5).

While these regulations provided new guidance towards strategic municipal spatial planning, statutory land-use planning was still confined to a highly complex and confusing legal environment due to the legacy of apartheid legislation. As claimed by the Minister of Land Affairs, "...the area of governance responsible for land, inherited an extraordinary legislative mess from apartheid" (South Africa, 2001). Land use planning and the authorisation of development applications continued to be managed and regulated within the traditional "town planning schemes" approach, which focused only on urban areas. A single zoning labelled "Agriculture" was assigned to rural areas, even though agricultural practices had very little to do with the actual land use (Interview with Mr. W Fourie). For this reason, the Minister of Land Affairs proposed to introduce new legislation to parliament, providing a uniformed, effective and efficient framework for spatial planning and land use management in both urban and rural context (South Africa, 2001). This led to the signing of the White Paper on Spatial Planning and Land Use Management in 2001. The White Paper was strongly influenced by Chapter 10 of Agenda 21, and called for an improved approach to integrated planning for sustainable management of land resources (South Africa, 2001). However, the White Paper remained "just" a White Paper for many years to follow.

3.5 South Africa's key socio-economic development strategies 2000 - 2010

The review of key national socio-economic policies and strategies adopted post 2000 indicate that government remained focused on stimulating economic growth as targeted in the GEAR, and on land and water reform.

While economic growth averaged at around 3%, which was considerably higher than previous years, rural areas remained characterised by high levels of poverty, unemployment and a lack of access to basic services (The Presidency, 2005:2).

In response to the rural challenges, government adopted a new Integrated Sustainable Rural Development Strategy (ISRDS) in November 2000. The ISRDS strategic objective was to ensure that by the year 2010, the rural areas would attain the internal capacity for integrated development (The Presidency, 2000:1). Key to the strategy was to get community members involved in the IDP process to identify priority areas where “Baskets of Services” were required (The Presidency, 2000:14). Once communities expressed their needs, the needs assessment will translate into municipal programmes (The Presidency, 2000:27). It was anticipated that the bottom-up approach would lead to quicker implementation and service delivery (The Presidency, 2000:24). However, the initial response of the post-1996 policies was to continue promoting growth in areas that had the existing advantage of economic agglomerations with the hope that this would trickle down to rural areas. Unfortunately, this hegemonic economic planning paradigm further promoted the development of strategic urban areas while rural areas remained under-developed (RDLR, 2014a:2-5).

3.5.1 South Africa’s areas-based approaches to capital spending

To address the challenge, the President announced two new programmes in 2001, which were derived from the ISRDS: the Integrated Sustainable Rural Development Programme (ISRDP) and the Urban Renewal Programme (URP). Both programmes were defined as area-based approaches (ABA) to development, as capital spending were priorities for 14 rural and 8 urban nodes (Everatt & Smith, 2008:7). The aim of the ABA was to “crowd-in” opportunities; mobilise local partnerships; strengthen public participation; and to create a hot-house for broad-scale development (Forster *et al.*, 2006). However, neither the ISRDP nor the URP adequately lived up to their promise (Public Service Commission, 2010:79). One of the reasons was that “decision-makers had no spatial criteria to guide the choices they made; instead, most choices were made in terms of those communities that attracted the most attention” (The Presidency, 2003:6).

In 2003, government aimed to address the issue of ‘lack of spatial guidance’ as identified in the ISRDS, ISRDP and the URP by adopting a National Spatial Development Perspective (NSDP) in 2003 (The Presidency, 2003:6). The NSDP was an indicative framework to inform decisions on infrastructure investment and development spending, as it gave clear direction as to where urban and rural investment should take place (The Presidency, 2003:16-18). The 2003 NSDP also noted that “several development programmes, including housing programmes, did not address the distortions of the inherited apartheid space economy” (Ibid.).

Part of the problem lied within the development-driven model where developers had been taking advantage of available land at a lower cost on the periphery, rather than to spend on well-located land within major urban centres (see discussion of DFA). “This disconnected development trend not only created unsustainable urban forms, it also encroached on high-value agriculture land and scenic locations that had tourism potential” (The Presidency, 2003:30).

In a response to address the concerns raised by the ‘development-driven model’ of low-income housing schemes, the Department of Housing (DoH) developed a Comprehensive Plan for the development of sustainable human settlements, also referred to as the “Breaking New Ground” (BNG) in 2004. The plan emphasised the need to move away from a housing-only approach to a more holistic development of human settlements, including the provision of social and economic infrastructure (DoH, 2004). The BNG promoted human settlements that are compact, have mixed land uses and have life enhancing environments with maximum possibilities for pedestrian movement and transit (DoH, 2004:11). The BNG also encourages social housing to be of medium-density that provides infrastructure services through alternative technology and design. The BNG strategy did not specify which technologies it was referring to but did note that the “Department will investigate measures and incentives to enhance housing design and promote and alternative technologies...” (DoH, 2004:16). One such strategy that were to address and promote the use of alternative technologies with regard to water services, was the National Water Resource Strategy (NWRS).

3.5.2 South Africa’s 1st edition NWRS

The National Water Act requires the NWRS to address all matters related to the protection, use, development, conservation, management and control of water resources for the country as a whole (DWAF, 2004a). However, the NWRS only mentioned rainwater harvesting once (considered as an alternative source of water), stating that “Rainwater harvesting from roofs or other hardened surfaces, using tanks, small check dams or catch pits can supplement more conventional sources of supply...” (Ibid.:66). Nevertheless, the NWRS (DWAF, 2004a:148) contributed to the aims and programmes of the ISRDP and the URS by prioritising water resources management programmes in areas identified in the ISRDP.

The NWRS provided other options for reconciliation interventions, which included “water demand management; improved resource management and conservation; the management of invasive alien vegetation; the re-allocation of water; the development of surface water resources and the inter-catchment transfer of water; and increased use of groundwater” (Ibid.:78-90). The latter became a focus point for the Department as the increased use of groundwater played a pivotal role in rural water supply (Ibid.:15).

In terms of water quality, the NWRS identified agricultural drainage and wash-off; urban drainage and effluent return flows; industries wash-off and return flows; mining activities; and areas with insufficient sanitation services as the country's major sources of surface water pollution. Groundwater is mainly polluted from mining activities, leachate from landfills, human settlements and intrusion of sea water (Ibid.:23-24). Of utmost importance to this study, is the fact that the 2004 NWRS recognises the potential influence of land use practices, e.g. impervious surfaces in urban areas on the proportion of runoff that reaches streams or penetrates the surface, and its water quality impact. However, in-depth reporting on these factors were deemed beyond the scope of the 2004 NWRS (Ibid.:38) and referred to land use and climate change as "other factors influencing water availability and water requirements" (Ibid.:38).

3.5.3 Environmental reform

As several national strategies highlighted the concerns of environmental discourse, parliament promulgated two new acts, the National Environmental Management: Protected Areas Act No 57 of 2003 and the National Environmental Management: Biodiversity Act No 10 of 2004 (DEA, 2015). Together with NEMA, the trio of acts facilitate the legal protection, conservation, planning and management of the country's biodiversity.

The Protected Areas Act enabled National Government, acting through the Minister, the authority to declare areas as protected areas. The objective was to protect the viability and integrity of ecologically sensitive areas (South Africa, 2003). The Act aimed to establish an interrelationship between natural environmental biodiversity, human settlements, and economic development (Section 17(a-j)) (South Africa, 2003).

As for South Africa's biodiversity, the Biodiversity Act mandated the minister to prepare and adopt a National Biodiversity Framework (Section 38(a)) that provides for an integrated, co-ordinated and uniform approach to biodiversity management (Section 39(1)(a)) (South Africa, 2004a). As such, the Department of Environmental Affairs and Tourism (DEAT) commissioned the country's first ever comprehensive spatial biodiversity assessment. The assessment findings were published in 2004 as part of the National Spatial Biodiversity Assessment (NSBA) report. The 2004 NSBA mainstream rivers assessment revealed that "26% of quaternary catchments were intact (category A or B), whereas 48% were moderately modified (category C), and 26% transformed (categories D-F). The rivers assessment also revealed that out of 120 signature rivers, 82% were threatened of which 44% were critically endangered, 27% endangered, 11% vulnerable and 18% were least threatened.

At the time, no wetland ecosystems were assessed due to a lack of appropriate national data on wetlands". Yet the assessment made it clear that multiple demands from urban settlements, agriculture, and industry have had a major impact on the country's already scarce water resources; while rapid and uncontrolled land cover change was identified as the single biggest cause of loss of biodiversity in the country (Driver *et al.*, 2004:6-33). The NSBA also raised concerns about the country's existing national protected area system, which did not adequately conserve a representative sample of the country's biodiversity, nor did it adequately maintain key ecological processes across the landscape and seascape (DEA, 2010:16; SANBI, 2014a:73).

The spatial component of NSBA later informed the 2005 National Biodiversity Strategy and Action Plan (NBSAP), which defined the long-term strategy for the conservation and sustainable use of South Africa's biodiversity (SANBI, 2016) (DEAT, 2005:27). The NBSAP listed several strategic objectives to be reached within the next 15 years. The NBSAP identified, amongst others, the need to create an enabling policy and legislative framework to integrate biodiversity management objectives into the broader economy, to develop a network of conservation areas, and maintain key ecological processes across landscapes (DEAT, 2005:28-30). Ultimately, the key findings from the 2004 NSBA and the strategic objectives of the 2005 NBSAP led to the development of the 2008 National Biodiversity Framework (NBF).

3.5.4 South Africa's second decade of democracy

Within the passing of the first post-apartheid decade, most of the country's socio-economic strategies were criticised for lacking either a spatial or environmental component, while others lacked an economic or financial component. Nevertheless, economic growth reached an all-time high of 5% in 2004 (The Presidency, 2005:2). The DWAF (2004b:11) also reported that between 1994 and 2004 an estimated R8 billion in capital grants were paid towards municipal infrastructure programmes, more than 50% (R4.9 billion) of which was invested in urban and peri-urban water and sanitation services infrastructure schemes (DWAF, 2004b:11). According to the DWAF (Ibid.:15) an estimated 27.7 million people already benefitted directly from the Free Basic Water Policy.

While expectations for future economic growth was high, concerns about unemployment did not fade. Real income of the poorest 20% of South Africans rose by 30% between 1994 and 2004, while unemployment remained above 26% in 2005 (The Presidency, 2005:2). Government's response to the socio-economic shortfalls was to replace the 1996 GEAR strategy with a new macro-economic strategy called the Accelerated and Shared Growth Initiative for South Africa (ASGISA) in 2005. The strategy set lofty goals for socio-economic development, i.e. to reduce poverty by 2010, and halving unemployment by 2014.

ASGISA identified investment in public infrastructure as a response to achieving the set targets. It identified several large provincial projects that would contribute to job creation. However, it was not concerned with where local government infrastructure investment should take place, as this was to be addressed in the revised NSDP.

3.5.4.1 National Spatial Development Perspective 2006

The revised NSDP, adopted in 2006, aimed to “facilitate optimum alignment between infrastructure investment and development programmes within localities” (The Presidency, 2006:i). The difference between the 2003 and the 2006 NSDP was that the latter did not predetermine what should happen where, when and how. Instead, it provided for norms and principles designed to guide the investment and development spending of all spheres of government (Ibid.). The NSDP argued that “government’s social objectives would be best achieved through infrastructure investment in economically sustainable areas with proven development potential” (Ibid.). As such, “areas displaying little or no possibility of growth should only be provided with the constitutionally mandated minimum levels of services. In these areas, Government spending should rather be on the people, i.e. social development spending” (The Presidency, 2006). Furthermore, the 2006 NSDP encouraged compact, nodal urban development and discouraged investment of fixed infrastructure in marginal areas of limited economic potential. However, the 2006 spatial perspective was perceived to support an unbalanced national spatial development profile.

3.5.4.2 National Framework for Sustainable Development 2008

In 2008, a new wave of thinking emerged, one which was based on a systematic approach to sustainability “where the economic system, the socio-political system, and ecosystem services are embedded within each other, and integrated through the governance systems that hold all the other systems together in a legitimate regulatory framework” – see Figure 3-6 (DEAT, 2008:14). The National Framework for Sustainable Development (NFSD) was government’s first national applicable framework to spell out South Africa’s vision for a sustainable society. The vision states that “South Africa aspires to be a sustainable, economically prosperous and self-reliant nation that safeguards its democracy by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration” (DEAT, 2008:19).



Figure 3-6: 2008 NFSD Systems approach to sustainability

Source: DEAT (2008:19)

The NFSD assessed natural, social, economic, governance, and critical cross-cutting global trends and derived priority areas, or “pathways” to achieving sustainable development. In terms of governance and integrated planning the NFSD emphasised the need to integrate environmental considerations with government policies, laws, and strategies, and more specifically SDF. The NFSD also emphasised the need for soil rehabilitation and investment in alternative and sustainable infrastructure – broadly referring to green infrastructure investment. Most importantly, the NSDF called for sustainable human settlement strategies that promote densification and reduce urban sprawl (DEAT, 2008:32-40).

3.5.4.3 National Biodiversity Framework 2008

During the same year, the Minister of DEAT published the first NBF terms of Section 38 of the Biodiversity Act, which also emphasised the need for ecological sustainable development. The NBF shifted attention from “conserve OR develop” to “how and where to conserve AND develop” (DEAT, 2009:39). The framework reflected on other national economic and environmental strategies, including ASGISA 2005, NSDF 2006 and the 2008 NFSD. In terms of ASGISA 2005, the NBF noted that the targeted 6% growth rate would have major implications on the use of natural resources, especially water. Yet, the NBF claimed that it was possible to overcome the challenge if care was taken over the location, the type, and the consumption pattern of proposed developments (Ibid.:25). As for the 2006 NSDP, the NBF noted that it was “consistent with biodiversity conservation objectives, especially to the extent that it encourages compact, nodal urban development and discourage investment in fixed infrastructure in marginal areas of limited economic potential” (Ibid.:32).

In terms of the 2008 NFSD, which identified the need for greater integration between environmental considerations and other strategic plans (e.g. SDFs). The NBF proposed that the “how and where” of development should be addressed by provincial spatial biodiversity plans (PSBP). The NBF explained that PSBP were to be informed by various systematic biodiversity assessment processes, ultimately to identify critical biodiversity areas (CBA) and ecological support areas (ESA), and provided guidelines for land-use planning and decision-making in these areas. On a provincial spatial scale, PSBP should form the basis of bioregional plans published in terms of the Biodiversity Act, and should also be used to inform environmental assessment, EMF, and local and district Spatial Development Frameworks. The NBF also proposed that PSBP should inform authorities responsible for environmental conservation on ‘where’ possible expansion of protected areas could take place, as it was already known that the country’s existing protected area system was insufficient.

3.5.4.4 Medium Term Strategic Framework 2009-2014

In April 2009, South Africa’s 4th democratic elections took place where the ANC emerged as victors once again. The 2009-2014 Medium Term Strategic Framework captured Government’s 10 strategic priorities, some of which affected land and water resources directly (The Presidency, 2009:10-44). As for water infrastructure, the MSTF requires government to continue to build and maintain water infrastructure, improve reticulation, prevent wastage and ensure reliable and safe supply for human consumption, industrial activity and for agriculture (Ibid.:18). As for human settlements, the MSTF states that the finalisation of the Land Use Management Bill is critical for facilitating the development of sustainable human settlements (Ibid.).

3.5.4.5 National Groundwater Strategy 2010

The DWAF published its first ever National Groundwater Strategy in 2010, which emanated from the department’s internal directive to better understand this underutilised and misunderstood resource. The strategy noted that groundwater resources did not receive the same level of attention as surface water. Skilled water managers’ opinions were that it might relate to the system of water management introduced in the early 19th century (the riparian principle discussed in Section 3.2). As a result, spatial planning documents rarely consider groundwater, even where groundwater is a potential major factor in continued economic development (DWAF, 2010:11). Furthermore, the lack of understanding of the spatial elements of groundwater has also led to widespread deterioration of groundwater quality. The strategy blamed land use linked to various sectors, such as mining, industrial activities, effluent from municipal wastewater treatment works, stormwater runoff from urban and especially informal settlements, return flows from irrigated areas, and effluent discharge from industries” (DWAF, 2010:24).

These land use activities contributed to high levels of electric conductivity in several regions, causing groundwater to be brackish (DWAF, 2010:18). However, the strategy noted that South Africa's groundwater is generally safe to drink without treatment, and that groundwater resources will be "less directly and more slowly impacted by climate change compared to, for example, rivers (surface water) as the volumes are stored underground and do not evaporate as quickly as surface water resources" (DWAF, 2010:9). This soon led to the drafting of the 2011 Artificial Recharge Strategy for South Africa (DWA, 2010).

3.6 Government's new development path towards 2030

In December 2010, Government announced the adoption of a new economic strategy, the New Growth Path (NGP), which recognised that despite of all other national strategies, inequalities were deeper than ever before (The Presidency, 2010:10). During the same year, the Presidential Infrastructure Coordinating Commission (PICC) was established to assess South Africa's shortcomings and achievements since 1994. The Diagnostic Report published in 2011 highlighted major developmental challenges in terms of inadequate infrastructure; poor quality of public services; high levels of unemployment; high levels of corruption, and a resource intensive economy (Armitage *et al.*, 2014:30). The 2011 Diagnostic Report also noted that in future, the country should approach development needs differently, shifting from a paradigm of entitlement to a paradigm that promotes the development of capacities, the creation of opportunities and the participation of all citizens. To give effect to the future of development in South Africa, government announced the adoption of a National Development Plan (NDP) which lays down the long-term socio-economic development roadmap for the next 20 to 30 years (The Presidency, 2012).

3.6.1 South Africa's National Development Plan: Vision 2030

Regarding water resources, the NDP acknowledges that South Africa is a water-scarce country and emphasises that greater attention will need to be placed on the management and use of this resource (The Presidency, 2012:177). The NDP states a vision for water services that "Before 2030, all South African will have affordable access to sufficient, safe and hygienic sanitation to live healthy and dignified lives... the country's economic and social development will reflect an understanding of and an alignment with available water resources.... All main urban centres will have a reliable supply of water to meet their needs.... the natural water environment will be protected to prevent excessive abstraction and pollution" (The Presidency, 2012:177-187). The NDP target for water services is to reduce water demand in urban areas to 15% below the business-as-usual scenario by 2030 (The Presidaecy, 2012:179).

Regarding environmental sustainability, the NDP recognises that South Africa has a rich endowment of natural resource and mineral deposits, which can fund the transition of a low-carbon future and more diverse and inclusive economy (The Presidency, 2012:197).

The NDP's vision in respects of environmental sustainability and a low-carbon economy states that "By 2030, planning and investment in infrastructure and services will take into account climate change and other environmental pressures...invested in sustainable technologies and programmes to conserve and rehabilitate ecosystems and biodiversity areas...and have a land use policy and regulatory framework in place to determine the environmental and social cost of new developments" (The Presidency, 2012:199).

As for urban areas, huge differentiation in terms of spatial form, economic base and institutional strengths are observed (The Presidency, 2012:266). Other sources characterise the typical South African towns and cities as resource intensive, suffering from inefficiencies across sectors (energy, food, water, waste, and transport) (Turok & Borel-Saladin, 2014). While some decoupling has been observed in the energy sector, generally the development trajectory is unsustainable (SACN, 2016). Combined features of urban and rural settlements are also found in areas forming part of traditional land under the authority of traditional councils (DEA, 2014). In these areas, land use decisions are made on behalf of the community by the Tribal Chief. These decisions are often uninformed due to a lack of adequate planning and land-use management systems. Table 3-1 summarises South Africa's urban and rural settlements inefficiencies.

Table 3-1: NDP: Inefficiencies across urban and rural settlements

Rural inefficiencies	Urban inefficiencies
High cost of providing services and infrastructure in rural areas, especially in places that are remote and have low population densities.	As urbanisation continues, a large proportion of urban residents will be poor, reflecting a phenomenon referred to as the urbanisation of poverty.
Many rural settlements have population densities approaching that of urban areas but lack a mix of land-uses, urban economies, and infrastructure.	South Africa's towns and cities are highly fragmented, imposing high costs on households and the economy. Overall, little progress has been made in revising apartheid geography.
The current framework governing land in traditional areas is not working nor is it integrated with overall municipal spatial planning.	The relationship between where people live and how they survive is often overlooked.
Large areas of high-potential agricultural land are grossly underutilised in traditional areas.	Although cities are generally more resource efficient than scattered settlements, their concentration requires the development of large sources of energy and water, placing strain on the surrounding environments.
Rural areas have weak mechanisms to resolve spatial conflicts involving tourism, agriculture, mining rights, and protection of the environment, which are becoming increasingly acute as natural resources are depleted.	Continued urbanisation will result in increased water resource consumption and wastewater production as higher levels of services are provided in urban areas.

Source: The Presidency (2012:265-267)

Within the context of differentiation and inefficiencies of existing urban and rural settlements, the NDP provides a vision for each. The NDP's vision for rural settlements states that “By 2030, South Africa’s will have developed vibrant, productive rural communities that create and keep wealth in their areas and also provide benefits for the nation” (The Presidency, 2012:283). In achieving this vision, it is necessary to understand the rationale for investment in various types of levels services, e.g. innovative forms of services and infrastructure provision where conventional, fixed infrastructure may be unavoidable (The Presidency, 2012:283).

The NDP's vision for urban futures is less direct and states, amongst other things, that “... urban sprawl should be contained and possibly revised as denser forms of development are more efficient in terms of land usage, infrastructure cost and environmental protection... towns must be designed for long-term resilience and flexibility... and more attention should be given to the design and quality of urban public space” (The Presidency, 2012:285-286). However, solutions and strategies must be tailored to their unique circumstances.

The NDP criticised the existing spatial planning systems and called for an urgent and comprehensive review. According to the NDP, due to the complex division of powers and functions between local, provincial and national government, there is uncertainty about who is responsible for spatial planning. Furthermore, legislation that regulates land-use management is largely unreformed and dates back to apartheid. Provincial land-use management functions, such as agriculture, tourism and environmental management, overlap with municipalities, creating confusion and conflict (The Presidency, 2012:274-275). The NDP also called for a national spatial vision to be informed by overarching spatial principles, including Spatial justice; Spatial sustainability; Spatial resilience; Spatial Quality; and Spatial efficiency. Fortunately, parliament reacted to this which led to the enactment of new planning legislation.

3.6.2 Spatial Planning and Land Use Management Act No. 16 of 2013

In August 2013, the spatial planning system of South Africa underwent a dramatic reform as the long-awaited Spatial Planning and Land Use Management Bill (SPLUMB) was enacted in terms of section 155(7) and section 44(2) of the Constitution. It became the Spatial Planning and Land Use Management Act No 16 of 2013 (hereafter referred to as SPLUMA). Although SPLUMA was only set for implementation on 1 July 2015, it was the “first legislative measure to provide a unified spatial planning and land use management system for all of South Africa and all government levels” (Nel, 2016:80). SPLUMA addressed the concerns raised by the NDP, as it clarified the role and responsibilities of each sphere of government where spatial planning is concerned. Amongst others, Section 5 of the SPLUMA assigns the following planning responsibilities to:

- National government: "...the compilation, approval and review of spatial development plans and policies, including a national spatial development framework... execution of legislative and executive powers related to land... the making and review of policies and laws necessary to implement national planning";
- Provincial governments: "...the compilation, approval and review of a provincial spatial development framework... monitor, approve and review municipal land use schemes... execution of its legislative and executive powers related to land... the making and review of policies and laws necessary to implement provincial planning";
- Local government (municipalities): "...the compilation, approval and review of integrated development plans; spatial development frameworks and a land use scheme... and the control and regulation of the use of land within the municipal area where the nature, scale and intensity of the land use do not affect the provincial planning mandate of provincial government or the national interest".

SPLUMA created a spatial planning system that integrates policy, spatial planning and land use management, especially at local government level, to address the inclusion of people and spaces that were previously excluded from the development framework (Strauss & Liebenberg, 2014:434). The act also mandates that all plans should give effect to the spatial principles, including Spatial justice; Spatial sustainability; Spatial resilience; Spatial Quality; and Spatial efficiency as called for by the NDP.

The SPLUMA also mandates that spatial planning and land use management practices adhere to all other legal requirements to reflect the spirit of relevant legislation, such as the Constitution Act of 1996 and the Municipal Systems Act No. 32 of 2000, which set out the principles of co-operative governance and the duties and objectives of local government, including alignment of all plans. Moreover, spatial planning and land use management must adhere to environmental legislation, including NEMA, the Biodiversity Act, and the Protected Areas Act. The National Water Act and the Water Services Act also fall within the description of relevant legislation; however, SDFs and LUS hardly ever mention these acts – hence the unsustainable trajectory of land and water resource planning and management.

3.6.3 Second generation strategies

Between 2010 and 2018, many existing national assessments, reports and strategic plans were either reviewed or replaced, hence the heading, "second generation strategies". To start with, the 2004 NSBA was reviewed and published as the National Biodiversity Assessment in 2011 (detailed discussion on the findings is provided in Chapter 4). Furthermore, the 2005 NBSAP was reviewed, updated and published as the National Biodiversity Strategy and Action Plan (NBSAP) 2015-2025.

The NBSAP 2015-2025 developed six strategic objectives, such as “managing biodiversity assets and their contributions to socio-economic development... investment in ecological infrastructure to enhance resilience... mainstreaming biodiversity considerations into other sector policies, strategies and practices... mobilise people to adopt practices that sustain the long-term benefits of biodiversity... build effective knowledge foundations for the sustainable management, conservation and use of biodiversity” (DEA, 2015:22).

The DWS reviewed both the 2004 NWRS and the 2010 National Groundwater Strategy, publishing the second edition NWRS-2 in 2013, and the second edition National Groundwater Strategy in 2016. The two strategies will be discussed in more detail as they provide important information on the current and future state of water resources in South Africa.

3.6.3.1 NWRS-2 and National Ground Water Strategy 2016

The NWRS-2 acknowledged that much had changed since 1994, including the adoption of new legislation and policies providing a progressive water management framework and providing access to water and sanitation services for millions of South Africans. However, the NWRS-2 states that “although the regulatory framework and institutional arrangements have changed since the advent of democracy, one aspect remains constant: water scarcity – whether quantitative or qualitative or both – which originates as much from inefficient use and poor management as from real physical limits and the potential impact of climate change” (DWA, 2013). Furthermore, the NWRS-2 raised concerns that socio-economic growth will potentially be restricted if water security, water quality and associated water management issues are not resolved.

The NWRS-2 reflected on the findings of several water reconciliation studies conducted in major urban areas and major towns. These studies provide insights into future water demand and supply to be addressed by reconciliation strategies. The NWRS-2 strategic response to securing future water resources included the implementation of water resource mix and sustainable resource management through effective protection and conservation and proficient governance. The measures to secure future water demand in most reconciliation strategies defaulted to high-level, traditional approaches such as developing surface water resources through conventional fixed infrastructure. Only four strategies identified groundwater resource development as a possibility, while two strategies identified the removal of alien invasive plants as possible measures. The above proposed interventions are in fact contradictory to the NWRS-2 statement that there is a need to include alternative water sources in its bulk water calculations (note by the Author).

As for groundwater resources, NGS (DWS, 2016b) states that the role of groundwater will significantly increase as surface water resources are already limited in many catchments. However, the National Groundwater Strategy noted that groundwater remains unrecognised as a valuable resource by land use planners, resulting in poor coordination between groundwater development and the use of land for human settlements and other purposes (Rowlston, 2011:25). Nevertheless, the 2016 National Groundwater Strategy identified the need for, amongst others, a responsive groundwater regulatory framework; groundwater resource protection; sustainable groundwater resources utilisation; and groundwater resources planning and development.

3.6.4 International obligations

At the Summit for the adoption of the 2030 Agenda for Sustainable Development (United Nations, 2015:5) a new Agenda, informed by the outcomes of, amongst others, the 1992 Rio Declaration on Environment and Development, 2000 Millennium Summit's MDG, and the 2002 World Summit on Sustainable Development, was adopted. The 2030 Agenda for Sustainable Development was accompanied by a new set of goals (17 goals with 169 targets) which came into effect on 1 January 2016 (United Nations, 2015:10). These goals are to guide national, provincial and local municipalities decision-making processes for the next 15 years, while the targets offer a yard stick for performance measurements (United Nations, 2015:5). Two of these goals are directly related to strategic water-resource planning and management, and human settlements.

With regard to water specifically, Goal 6 aims to “ensure availability and sustainable management of water and sanitation for all: by 2030, achieve access to safe drinking water for all; access equitable sanitation; improve water quality; increase water-use efficiency; implement IWRM at all levels; and protect and restore water related ecosystems.”

With regard to human settlements, Goal 11 aims to: “make cities and human settlements inclusive, safe, resilient and sustainable: by 2030, ensure access to housing and basic services; inclusive and sustainable urbanisation; protect natural heritage; reduce the number of deaths caused by water-related disasters; reduce the per capita environmental impact of cities; and improve access to green and public spaces” (United Nations, 2015:22-26).

The prospects of cities playing a vital role in promoting sustainable development is more promising than ever, as several of the SDGs “can in fact be achieved when focus is placed on the way in which spatial planning and land use management is implemented” (Georg, 2015:327). However, spatial planning and land use management can also have an opposite impact when planned without taking other sectors into consideration.

Globally, the human consumption of land is greater than ever, and the mismanagement of land uses carry serious environmental consequences (Sustainable Cities Institute, 2012). Nonetheless, since the beginning of the 21st century, several countries and private developers have directed funding towards research and development of more sustainable cities. This could be linked to the initial mainstreaming of sustainable development principles within planning and development processes as promoted by the United Nations' Habitat I, Habitat II and Agenda 21.

However, not until recently did attention shift towards a more inclusive and integrated way of sustainable water resource management. Today, water sensitivity as a broader theory in spatial planning and land use management has gained global awareness as the risks associated with climate change and increasing resource demands due to population growth and urbanisation continue to escalate at an alarming rate. In response to the SDG and to combat the water-related challenges, the aspirational concept of the Water Sensitive City emerged in scientific, policy, and spatial planning domains as an alternative approach to water resource management and service delivery.

3.7 Conclusion

South Africa's hydrosocio contract, as depicted in this Chapter, reveals that since the early 1800s the relationship between land and water was established through legislation, more specifically the riparian principle – brought to South Africa by Western cultures. This principle not only deprived the majority of Black South Africans from having access to water resources; it also led to groundwater resources being underutilised and often misunderstood, as this resource was considered separate to surface water resources. Since South Africa's early era of development, water scarcity and severe drought conditions have had a major impact on where communities reside, leading up to South Africa's first signs of rapid urbanisation in the early 1900s. This also led to new departures in urban planning. Unfortunately, these new departures soon resulted in segregated development in support of the ruling party's social and political agenda. While the ruling party and its aims have since completely changed, the spatial impact of those decisions can still be observed today.

From a global perspective, the development trends of the late 20th century raised concerns that brought about a new wave of thinking within the development domain. Today it has become widely accepted as part of policy goals and practice objectives, nationally and internationally (Georg, 2015:327; Sharifi & Murayama, 2013:83). The terms 'sustainable development' and 'sustainability', has been around since the early 1950s, encapsulated in different disciplines and sector-specific ideas and ideals. The concept of eco-city development was one such idea to give effect to sustainable development from a spatial planning perspective.

The water sector also made a paradigm shift by introducing the concept of IWRM in the 1970s as the new way through which water resource planning and management will be conducted. Although IWRM did not gain true value up until the early 1990s, South Africa was no stranger to this concept. In fact, IWRM was adopted and South Africa's new water policies and legislation drafted after the fall of the Apartheid regime. However, it was primarily focused on infrastructure provision, water pricing and governance as South Africa embarked on an ambitious programme to eradicate water backlogs as envisioned by the RDP. It resulted in government's focus being predominantly on supply management rather than demand management.

Throughout history (and at an ever-increasing tempo), the literature review revealed that South Africa has been pro-active at establishing policies and plans and creating various pieces of legislation aimed at addressing issues of national importance, e.g. growing the rural economy and eradicating the services backlog. Unfortunately, little reform in the spatial planning domain took place during South Africa's first era of democracy. An array of different spatial planning and land use management policies remained in place, contributing to a fragmented and distorted urban planning and development phase.

South Africa's hydrosocio contract reveals that planning for land and planning for water lacked critical integration. As stated by Woltjer & Als (2007), "the majority of decisions around water management were made without reference to spatial planning issues related to urbanisation and population growth, and conversely development and land-use decisions were made with little consideration of their effects on water systems." According to Thomson-Smeddle & Roux (2016), this trend is still seen today, primarily due to the continued predominance of old approaches to township planning, infrastructure and housing design, and a lack of cross-sector integration and collaboration.

However, changing this trend should be possible as the provision of water and the management of infrastructure are most often the responsibility of local government; the same institution is also tasked with the management and approval of land uses. The integration of land use and water resources planning should accordingly not be seen as a challenge but as an opportunity. Achieving water security will require a shift in thinking for all sectors, which cuts across traditional disciplinary, professional and administrative boundaries. From a spatial planning perspective, South Africa's recently enacted Spatial Planning and Land Use Management Act comes to the fore as a tool which could be used to secure future water resources.

The acknowledgement of major global issues of environmental degradation and resource depletion, as well as the deterioration of living standards, have contributed to the collective agreement that sustainability is no longer a minor developmental issue, but a trans-disciplinary challenge that must be placed at the forefront of the development agenda.

As a result, Chapter 4 will elaborate on South Africa's existing water resource situation, the country's existing regulatory and strategic planning framework governing land, water and environmental resources, and reflect on opportunities for water sensitive development.

CHAPTER 4 WATER SENSITIVE DEVELOPMENT

4.1 Introduction

By the end of the second millennium, the concept of sustainable development was embedded in almost every international and national policy framework. Yet, unsustainable patterns of urbanisation, resource consumption, and pollution continue at an alarming rate. There is global recognition that cities of the 21st century will be working in an entirely new context. As noted by Beck (2000) “we have arrived in a new era of uncertainty, where energy, water and food supply are critical”. Despite the number of conferences, multilateral agreements, local legislation, policies and plans opting for integrated and sustainable development, many countries, like South Africa, still lack critical integration of land and water resource planning and management.

Section 4.2 provides a status quo assessment of South Africa's water resource situation, presenting an overview of South Africa's physiography, considering factors such as topography, climate, rainfall, evaporation, runoff, and groundwater. The aim of this section is to emphasise the spatial and temporal variations in the natural distribution of water resources. This is a very important concept to grasp as not one municipality will have the same quantity or quality of water resources with which to plan. Sections 4.2.1.1 to Section 4.2.1.3 provides information on the current state of freshwater ecosystems, which according to the various sources, have to date been severely impacted by land use. South Africa's physical infrastructure, resource mix, and current issues and challenges related to the country's water and water distribution networks are discussed in Section 4.2.2. A brief discussion on South Africa's regulatory and statutory planning approach for water and environmental resource is provided in Section 4.2.3. The review is brief – placing focus on how these required plans and the information contained within, should be used to inform spatial planning and land use management practices.

Section 4.3 provides an in-depth review of two key publications with regard to water sensitivity. This section presents a short history or origin of the concept of water sensitive developments, defines water sensitivity within South Africa, and offers key information about opportunity for change. Section 4.4 focuses on the concept of Water Sensitive Spatial Planning as a means to give effect to achieving WSS. The section provides an in-depth discussion of tool planning tools, the municipal SDF and the municipal LUS, and established the link between SuDS, WSUD and WSSP. Section 4.5 draws a conclusion. This chapter is structured as follow (see Figure 4-1):

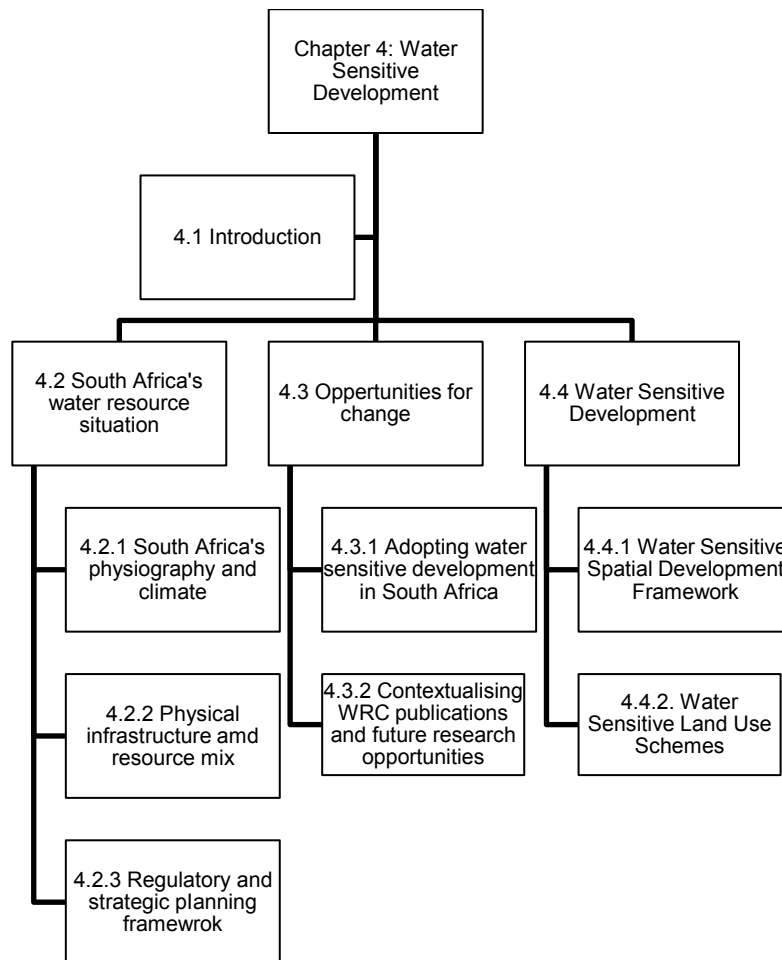


Figure 4-1: Conceptual structure Chapter 4

Source: Own Construction (2018)

4.2 South Africa's water resource situation

Water security is a critical challenge confronting South Africa and the world in the 21st century. Water security presents a profound challenge to South Africa's social wellbeing and economic growth. It could also become rapidly worse as supply contracts and demand escalate due to growth, urbanisation, unsustainable use, degradation of wetlands, water losses, and a decrease in rainfall due to climate change.

4.2.1 South Africa's physiography and climate overview

Stretching across 22°S to 35°S latitude and over 17°E to 33°E longitude, South Africa's total surface area covers 1 219 090 km². Due to South Africa's relative location to the equator, large parts of the country's interior, mostly towards the west, experience hot or cold arid desert climates typically associated with Köppen Climate Zone B (see Section 2.2). The country's eastern interior is slightly less arid, with dry winters and hot summers, and humidity levels increasing towards the eastern coastline.

As for South Africa's topography, "an invariant feature of physical landscape explains much of the country's climate features and hydrological responses" (Schulze, 2011:8). South Africa has generally low altitudes ranging between 0 – 400 m along the coastline, with generally cooler maximum summer temperatures ranging between $< 24^{\circ}\text{C}$ and 26°C . As the altitudes increase along the east and south coast towards the Great Escarpment, maximum annual summer temperatures decrease to below 24°C . In areas with declining altitudes, maximum annual summer temperatures increase from 27°C in the east to extreme highs of over 31°C to the west.

Due to the gradual north to south, yet slightly rapid east to west altitude and temperature changes, spatial and temporal variations in mean annual precipitation (MAP) can be observed. South Africa experiences average Mean Annual Precipitation (MAP) of less than $500\text{ mm}^{\text{yr}^{-1}}$, which is less than half of the global average (DWS, 2017a:9; Nel & Driver, 2015:1; Colvin & Muruven, 2017:8). Between the eastern coastline and South Africa's Great Escarpment, irregularities in altitudes cause severe fluctuation in MAP, ranging between $600\text{ mm}^{\text{yr}^{-1}}$ and $1\,000\text{ mm}^{\text{yr}^{-1}}$, decreasing to a low of $200\text{ mm}^{\text{yr}^{-1}}$ towards the southern coastline. According to Schulze (2011:9) the overall feature of South Africa's MAP distribution is that it decreases uniformly westwards from the escarpment across the interior plateau from approximately $1\,000\text{ mm}^{\text{yr}^{-1}}$ to less than $200\text{ mm}^{\text{yr}^{-1}}$. King *et al.* (2011:2) noted that 21% of the country receives less than $200\text{ mm}^{\text{yr}^{-1}}$. Most of the 21% is found within the warm interior plateau towards the west of the Northern Cape.

The combination of low altitudes and high temperatures causes South Africa to experience high evaporation rates averaging at $1\,800\text{ mm}^{\text{yr}^{-1}}$ (Colvin & Muruven, 2017:7). According to the Agricultural Research Council's (ARC) spatial data and mean annual evaporation database, the lowest evaporation occurs along the east to south coastline, remaining relatively low towards the Great Escarpment. Like the temperature observations, evaporation increases uniformly westwards from the escarpment across the interior plateau from approximately $1\,601\text{ mm}^{\text{yr}^{-1}}$ to $2\,400\text{ mm}^{\text{yr}^{-1}}$, increasing rapidly towards the Northern Cape to $> 2\,401\text{ mm}^{\text{yr}^{-1}}$. In most regions across South Africa, the evaporation rate is three times higher than the precipitation rate, resulting in a very low MAP:MAR ratio (the rate at which precipitation is converted into runoff) of 8.6% (Davies *et al.*, 2006:550). According to the Department of Water and Sanitation's (DWS) spatial data, 75% of the country's catchments have a mean annual runoff (MAR) potential of less than $100\text{ mm}^{\text{yr}^{-1}}$, found mostly north-west of the Great Escarpment across the country's vast interior.

Only 25% of catchments have relatively high volumes of runoff, ranging between $100\text{ mm}^{\text{yr}^{-1}}$ and $>500\text{ mm}^{\text{yr}^{-1}}$. These areas are limited to Eswatini (formerly known as Swaziland), Lesotho, and most of the Eastern Cape, decreasing southwards over KwaZulu-Natal and Western Cape with some catchments producing less than $20\text{ mm}^{\text{yr}^{-1}}$.

Disproportionately high volumes of runoff, at least three times more than that of the primary catchment, are produced by several catchments across the country and are referred to as South Africa's Strategic Water Source Areas (SWSAs) of national importance (DWA, 2013a:42; Nel *et al.*, 2013:7). SWSAs are defined as areas of land that either: (a) supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size; or (b) have high groundwater recharge potential; or (c) areas that meet both criteria (a) and (b) (Biodiversity GIS, 2018). They consist, therefore, of both surface water (SWSA-sw) and groundwater (SWSA-gw) resources.

The DWA (2013a:42) describes SWSAs as "...foundational infrastructure on which a great deal of built infrastructure for water services depend", which should be treated as "strategic national assets that are vital for water security and need to be acknowledged as such at the highest level across all sectors". The SWSA-sw spatial data reveals that South Africa has 22 SWSAs found predominantly within the high-altitude areas. SWSA-sw covers approximately 9% of the total geographic areas (including Lesotho and Eswatini), supplying 50% of the country's mean annual runoff (MAR). The bulk of 80% is generated by 3.9% of land found in South Africa alone (Nel *et al.*, 2013:21; Driver *et al.*, 2012:157). Unfortunately, only 18% of the country's SWSAs are formally protected (Driver *et al.*, 2012:71).

Groundwater differs from surface water in its response to rainfall, as it is not "flashy", but reflects over a period of months or even years (DWS, 2016b). However, like surface water, South Africa's aquifer recharge potential does not occur uniformly across the country as it is mainly dependent on rainfall and geological permeability (Ibid.: 11). South Africa has 37 SWSA-gw of national importance, covering approximately 8% of the country's subsurface area, and 20 SWSA-gw of sub-national importance covering approximately 2% of South Africa's subsurface area. These catchments' baseflow is at least 11-25 mm/year (Biodiversity GIS, 2018). The geographic extent of South Africa's SWSA-sw and SWSA-gw is illustrated in Figure 4-2.

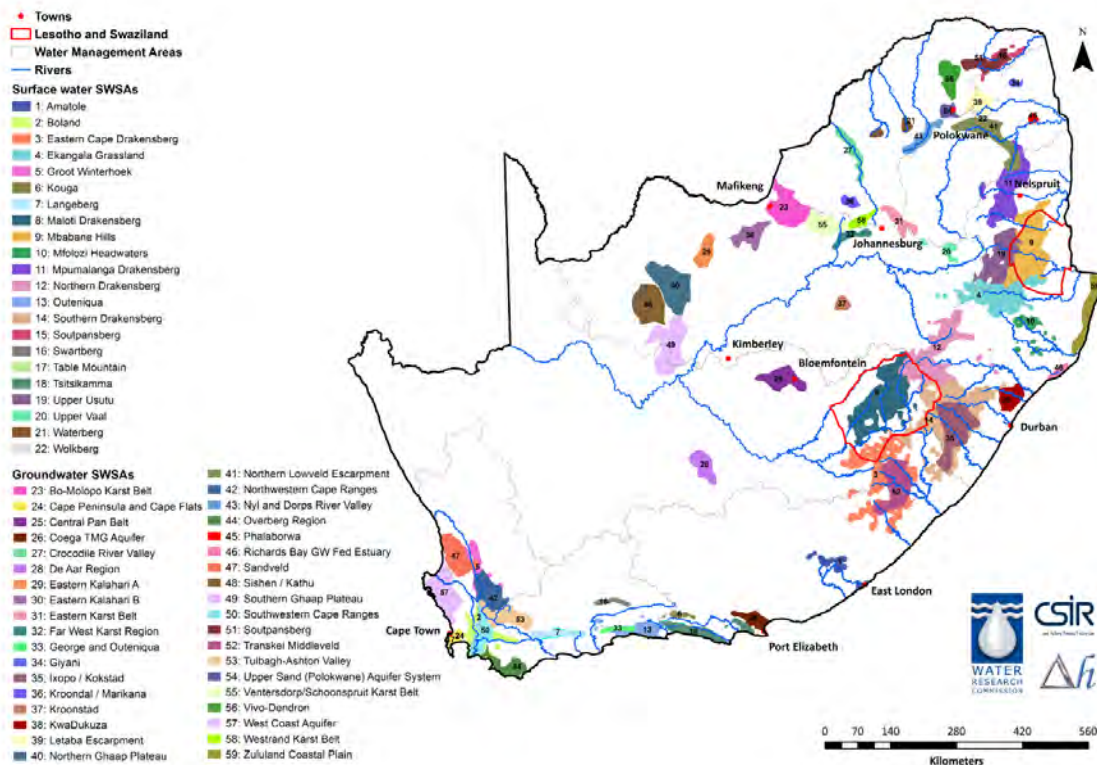


Figure 4-2: SWSA-sw and SWSA-gw including transboundary areas

Source: Biodiversity GIS (2018)

South Africa also has a range of freshwater ecosystems, including rivers, wetlands, and estuaries ranging from sub-tropical in the north-eastern part of the country, to semi-arid in the interior, to the cool and temperate rivers of the fynbos belt (Driver *et al.*, 2011:1).

4.2.1.1 River ecosystems

South Africa's linear river ecosystems stretch over 172 998 km. These rivers are vital for supplying, storing and transporting water throughout the country (DWS, 2017b:48). Unfortunately, South Africa only has 62 remaining free-flowing rivers that flow undisturbed from its source to the confluence with another large river or to the sea (Nel *et al.*, 2011:37). Based on their representativeness, their importance of ecosystem process, and biodiversity value, only 19 have been identified as flagship free-flowing rivers. According to the DWA (2013a:3), 60% of the river flow arises from 20% of land area, making land use a determining factor of their ecological condition (DWS, 2017b:48). According to Nel *et al.*, (2011:51), rivers with healthy natural vegetation along their banks are able to filter pollutants from the surrounding landscapes and are likely to have better water quality.

As most of the country's riparian areas have been impacted by some form of development, whether urban development, mining or cultivation, more than 65% of the country's main rivers have deteriorated. According to the 2011 NBF, 57% of the country's river ecosystems are threatened, 26% critically endangered, 19% endangered, and 13% vulnerable (Driver *et al.*, 2012:67). This is partly because only 14% of the country's 223 river ecosystems are well protected (Ibid.).

4.2.1.2 Wetland ecosystems

South Africa has 791 wetland ecosystem types, covering an estimated 2.4% of the country's surface areas (Driver *et al.*, 2012:80; Nel *et al.*, 2011:52). This 2% of wetlands surface area provides vital ecosystem services, including water purification, and regulation of water flows acting as sponges that store water, releasing it slowly – easing the impact of droughts and floods in the process, and supporting a diversity of animal and plant species (DWS, 2017b:85). South Africa also has 4 831 wetland clusters that represent groups of wetlands embedded in a relatively natural landscape, providing critical ecological processes (Nel *et al.*, 2011:13).

According to Driver *et al.*, (2011:13) all wetlands are of strategic national importance, yet only 11% of South Africa's wetlands are well protected, while 71% have no legal protection at all (Ibid.:80). The lack of legal protection, coupled with other development pressure largely driven by cultivation, urbanisation, mining, dam construction and poor grazing practices, has caused 48% of wetlands to become critically endangered, 12% endangered, 5% vulnerable and a remaining 35% to be least threatened (Driver *et al.*, 2012:77). In many parts of the country wetland clusters no longer exist because the surrounding land has become too fragmented by human impacts (Nel *et al.*, 2011:13).

4.2.1.3 Estuarine ecosystems

Estuarine ecosystems are formed where freshwater from rivers runs out to sea, acting as nursery areas for commercially important fish species (DWS, 2017b:86). South Africa has more than 300 estuarine ecosystems (Driver *et al.*, 2012), 122 of which have been identified as national priority estuaries (Nel *et al.*, 2011:56). Land use and land use activities such as damming, sand mining and other development close to estuaries have caused 43% of estuary ecosystem types to become threatened; 39% of which is critically endangered; 2% endangered and 2% variable (Driver *et al.*, 2012:8). According to the 2011 National Biodiversity Assessment only 33% of estuary ecosystem types are well protected, while 59% have no protection at all (Ibid.).

The concerning status of freshwater ecosystems is not caused by land cover change alone, as the construction of hydrological control sources such as dams, weirs and large-scale water transfers contributes to severe flow alterations in the form of over-abstraction, inter-basin transfers, and high return flows from urban areas. These alterations, e.g. timing, frequency, speed or volume of flow, are known to change the channel and habitat characteristic within, which in the end affects the quality of water and the integrity of aquatic life in rivers and wetlands (Nel *et al.*, 2011:5; DWA, 2011:2).

4.2.2 Physical infrastructure and resource mix

Under natural undeveloped conditions South Africa's average total mean runoff is estimated at just over 49 000 million m³/a (King *et al.*, 2011:4; DWS, 2013:8; WRC, 2016:8). According to Colvin & Muruven (2017:7) only an estimated low 9% (or 4 410 million m³/a) of the runoff ends up in rivers, causing high variability of water flow and very low to zero levels of river flow, while 4% (or 1 960 million m³/a) recharges groundwater aquifers. Only 30% of surface water can therefore be allocated at a high 98% assurance of supply. The estimated 15 000 million m³/a comprise 68% surface water; 13% groundwater; 13% return flow and 6% from other sources such as desalination (DWS, 2017a:8). However, the recently published 2016 Groundwater Strategy indicated that the initial estimated groundwater contribution of 13% (or 1 950 million m³/a), is less than current usage (DWS, 2016a). The strategy also reports that current groundwater usage is between 3 000 million m³/a and 4 000 million m³/a, and that the utilisable groundwater exploration potential (UGEP) is 7 500 million m³/a, allowing for factors such as physical constraints on extraction, potability, and maximum allowable drawdown (Ibid.:14).

The spatial location of economic activities coupled with complex population distribution patterns, underpinned by the promise of "Water for all", calls for sophisticated water-engineering systems. South Africa's water resource mix is made possible through a series of interconnected physical infrastructure, including dams, water transfers, distribution pipelines, water and waste water treatment works, boreholes, and desalination plants.

Today, South Africa has some 4 395 registered dams with an estimated combined storage capacity of 31 000 million m³, currently storing more than 66% of the country's mean annual runoff (MAR) (DWS, 2017b:15). Part of South Africa's water-engineering system is 28 inter-basin water transfer schemes with a total capability of 7 000 million m³/a, currently transferring approximately 3 000 million m³ per annum. South Africa's water reticulation infrastructure includes more than 290 000 kms of pipelines, 1 300 Water Treatment Works (WTWs), 1 363 registered Waste Water Treatment Works (WWTWs), 7 680 456 house connections, 5 078 545 yard taps and more than 2 146 146 street taps (Ibid.:28-43). The exact number of boreholes is undetermined.

For many years now, conventional water-engineering systems have been operating in both urban and rural settlements as it remains the sought-after solution to distribute water and wastewater over thousands of kilometres to where it is required at selected volumes as determined by consumer demand and resource availability.

4.2.2.1 Water resource allocation

South Africa's water infrastructure network currently distributes a total System Input Volume (SIV) of 4 046.46 million kl/a across the country. In terms of South Africa's major economic sectors resource demand, agriculture is the largest water user at an estimated 66% of the total water use, followed by municipal and domestic use at 27% and industrial at 7% (DWS:2015).

Regarding agricultural demand, high demand uses include irrigation of crops and water intensive grazing of livestock. Compared to other countries, the agricultural demand for water is generally higher, due to the country's climate and soil characteristic, which is extremely vulnerable to degradation and has low recovery potential (Galdblatt, 2014:7). According to Goga & Pegram (2014:10) only an estimated 12% (or 146 291 km²) of the country is suitable for growing rain-fed crops while only about 3% (36 573 km²) is considered truly fertile. Even though irrigated agriculture is by far the largest water consumer, only 1.5% of agricultural land is under irrigation, producing 30% of the country's crops (GCIS, 2009) cited by Goga & Pegram (2014), while 67% is used for grazing and livestock farming (DWS, 2015:10). According to Nel *et al.* (2011b) many of South Africa's rivers are over-abstracted by agricultural practices, leaving naturally perennial rivers now seasonal.

The major municipal water uses include water for gardening (35%), toilet flushing and personal hygiene (49%) in homes, schools, hospitals, commercial centres, and business (Colvin & Muruven, 2017:9). The 2016 Population Census Data indicated 74% of South African households have access to piped water inside their dwellings or yard, 15% have an access point outside of their yard, while 10% have no access to piped water (Stats SA, 2016).

The latter either received water from a borehole, rain-water tank or a water-carrier/tanker. However, some households only have access to water through a flowing water/stream/river, well, spring or other sources (Ibid.). In terms of sanitation, 60% of all households have access to a flush toilet connected to the sewerage system; 13% have access to either a Ventilated Pit Latrine (VIP), a chemical toilet, or a flush toilet with a septic tank. An estimated 0.3% of households have access to an ecological toilet, 2.2% of households still rely on bucket toilets, while the remaining 4% has no access to sanitation services.

Industrial water demand is roughly split between 53% manufacturing, 27% mining and 2% power generating. The high demand for water by manufacturing companies is mainly for processing minerals and crops, textiles and chemical refinement, and in some instances a component of auto manufacturing. One of the major concerns of industrial water use is the by-product of highly contaminated wastewater.

With a SIV of 4 046.46 million kl/a, South Africa's per capita consumption is estimated at 237 l/d, which is significantly higher than the international benchmark of 180 l/c/d (DWS, 2017b:58). This high water demand has severe issues related to the physical and hydrological integrity of physical infrastructure.

4.2.2.2 Issues and challenges with infrastructure services

The high water usage has caused WWTW to operate at close to 80% of its collective capacity, treating operational flow of 5128.8 ml daily (DWS, 2015:41). This means that 78.8% of the existing design capacity is accounted for by the current operational flows, leaving a theoretical surplus of 22.2% as available capacity for future demand (although many individual plants have no surplus and run at full capacity) (DWS, 2017a:50). DWS (2017b:28) reports that while 96% of all households have access to water services infrastructure, only 85% of households have access to operational services as 11% of schemes are currently dysfunctional. Furthermore, the DWS also reports that only 65% of households have access to a reliable RDP service (Ibid.). To this end, national water supply reliability is only at 65%, declining to 30% in District Municipalities (Ibid.:29).

In terms of performance, the 2014 Blue Drop Report indicated that 43% of WTWs were performing at average level, followed by 24% very poor and 17% in critical state (DWS, 2014:6-25). The 2013 Green Drop report further indicated that only 16% of WWTWs were performing at good to excellent; 34% were rated as average, while 20% were performing poorly and 30% of WWTWs were rated as critical (DWS, 2013:2). The current state and capacity of physical infrastructure is causing major resource insecurities, both in terms of quantity and quality, as many WWTWs discharge partially treated or untreated effluent back into the natural hydrological system. These unlawful actions can be traced back to the 50% of WTWs which are already in poor or critical state and operating at full design capacity. Treating effluent to an appropriate quality will become increasing more difficult as water demand continues to grow.

In South Africa, infrastructure challenges are exaggerated by the low density, sprawling characteristics of urban areas, where higher densities are often found on the outskirts of cities (DEA, 2014).

Unplanned and sparsely populated rural areas contain small pockets of higher density areas associated with some form of economic and transportation activity (Turok & Borel-Saladin, 2014), the direct water-related impact of which can be seen in the volume of water that is lost in the distribution network – increasing rapidly as densities decrease. The direct water-related impact of South Africa's settlement patterns is found in the country's Infrastructure Leakage Index (ILI), which is calculated at 5.3 on average (DWS, 2017b:56). The ILI also provides an indication of a system's non-revenue water (NRW) described by the International Water Association as the volume of water used by a municipality from which no income is received (DWS, 2015a:44).

In 2012, South Africa's NRW was recorded at approximately 39% (WRC Report TT 522/12), of which 2% is unbilled and unmetered water, followed by 37% apparent and real losses (DWS, 2017b:56), the highest percentage of which is found in the smaller, more rural Category B municipalities. In 2016, new data revealed that South Africa's NRW percentages increased to 41% (DWS, 2017:58). By halving water losses, this will mean an annual water saving of R2 billion per annum (DWS, 2015a).

Although South Africa's water resource challenges might seem daunting, the DWS and DEA adopted a strong regulatory and strategic planning framework, consisting of a hierarchy of mandatory strategies and plans. The following section provides a brief discussion on water and environmental resource planning – the focus of which pertains to how these plans can and should inform spatial planning and land use management.

4.2.3 Regulatory and strategic planning framework for water resources

South Africa has an extensive suite of legislation that mandates various spheres of government to prepare and implement strategic plans to guide development within its respective sectors. Although this thesis focuses on new ways to give effect to water sensitivity in terms of spatial planning and land use management practices, it cannot be achieved in isolation. It is of utmost importance for urban and regional planners to build a sound understanding of the regulatory and strategic planning environment in which both the water sector and the environmental sector operate. South Africa's main legislative framework providing for the protection, planning, development and management of all fresh or saline water resources includes the National Water Act No. 36 of 1998 and the Water Services Act No. 108 of 1997.

While the National Water Act is concerned with the protection, use, development, conservation, management and control of water resources, the Water Services Act provides the mechanisms for ensuring that all South Africans have access to a basic water supply and sanitation.

Both acts legislate the development of strategic planning documents to guide the planning and management of water resources on national level, down to local municipal level. South Africa has a long history, almost three decades, of systematic biodiversity planning which is firmly imbedded in both policy and practice (Nel *et al.*, 2011:7). The National Environmental Management Act No 107 of 1998 (NEMA) is the overarching framework act covering broad principles of environmental management and is regarded as the most important piece of general legislation. Under the auspices of NEMA, South Africa also adopted the National Protected Area Act No 57 of 2003 and the National Biodiversity Act No 10 of 2004. Likewise, both acts legislate the development of strategic planning documents to guide the planning and management of environmental resources on national level, down to local municipal level (see Figure 4-3).

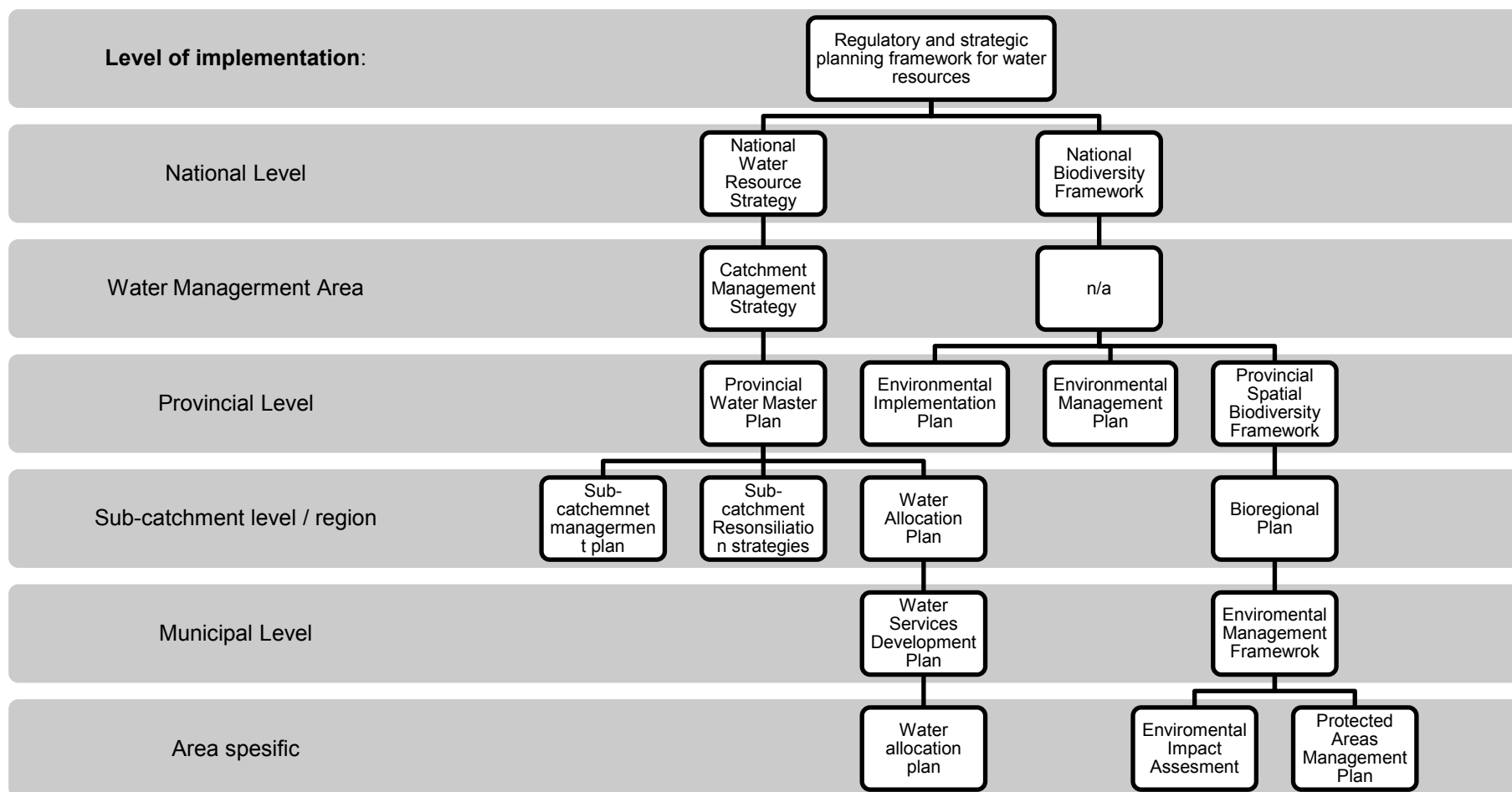


Figure 4-3: Regulatory and strategic planning framework for water and environmental resources

Source: Own Construction (2018) based on South Africa (1997a) and South Africa (1998a) and South Africa (1998b)

4.2.3.1 Strategic planning for water resources

National level: The NWRS is legally binding to all authorities and institutions exercising powers or performing duties under the National Water Act (South Africa, 1998a). Chapter 2 Section 6 of the National Water Act provides the mandatory requirements with which the NWRS must comply. Based on the prescribed content, Table 4-1 summarises the relevance of the NWRS to municipal spatial planning and land use management tools.

Table 4-1: Section 6(1) of Act no 36 of 1998

The NWRS must	Relevance to spatial planning and land use management
(b)...provide for at least actions to be taken to meet projected future water needs. (d)... contain estimates of present and future water requirements.	- A Spatial Development Framework is local governments key strategic plan concerned with future development. The actions prescribed by the NWRS to meet projected future needs should therefore be customised and spatialised to a municipality's specific needs. - Although very high-level estimates are provided reconciliation studies, decisions related to future spatial development and planning should be informed by these reconciliation studies as the defect in water resources is mostly likely caused by water intensive land uses.
(h)...set out principles relating to water conservation and water demand management.	- One of the NWRSs WCWDM principles states that water institutions should strive to supply and use water in an efficient and effective manner by minimising water losses and promoting WCWDM to their consumers. Promoting higher density development through the SDF and providing development incentives for higher density development by means of the municipal land use scheme can become a key contribution towards WCWDM.
(i)...state the objectives in respect of water quality to be achieved through the classification system for water resources provided for in this Act.	- Land use has a direct impact on water quality. In areas where the water quality objective as set through the classification system is not achieved, rehabilitation of land use should be the first priority. The municipal land use scheme should therefore be aware of the status of water quality as well as the water quality objective within its jurisdiction.
(l)...promote the management of catchments within a water management area in a holistic and integrated manner.	- Integrated water resource management includes the management of land and vice-versa. The management objectives and rules should therefore be understood by all sectors, especially local government as they have the constitutional mandate to provide both water services and spatial planning and land use management.

Source: Own construction (2018) adopted from South Africa (1998a:6)

Water Management Area: Catchment Management Strategies (CMSs) must integrate water resource management within the WMA as mandated by the National Water Act in terms of Section 8 (DWA, 2013b:64). Essentially the NWRS-2 provides the basis for the CMS. However, due to the CMS spatial scale, information contained in each CMS should be more detailed than that contained in the NWRS. Based on the prescribed content, Table 4-2 summarises the relevance of a CMS to municipal spatial planning and land use management tools.

Table 4-2: Section 9(1) of Act no 36 of 1998

A CMS must	Relevance to spatial planning and land use management
(a)...take into account the class of water resources and resource quality objectives contemplated in Chapter 3, the requirements of the Reserve and, where applicable, international obligations.	- As most water resources have some form of spatial reference, both the municipal SDF and land use scheme should include information on the management class, water quality targets, Resource Quality Objectives, reserve of its relevant catchment, and as far as possible implement spatial proposals and land use zoning.
(c)...set out the strategies, objectives, plans, guidelines and procedures of the catchment management agency for the protection, use, development, conservation, management and control of water resources within its water management area.	- These strategies, objectives, plans, guidelines and procedures should, as far as possible, include spatial references in order for spatial planners to utilise the information in their own sector plans. This will allow for optimal alignment between sectors responsible for water resource management and land use management.
(d)...take into account the geology, demography, land use, climate, vegetation and waterworks within its water management area.	- Much of the information required can be and should be retrieved from the municipal SDF and the land use scheme. These two planning documents should be used to inform the CMS holistic status quo assessment.
(f)...take account of any relevant national or regional plans prepared in terms of any other law, including any development plan adopted in terms of the Water Services Act, 1997 (Act No. 108 of 1997).	- This section facilitates the integration between land and water resources as it mandates the CMS to consider any relevant national or regional plan prepared by any other law – which includes the National SDF, Regional SDF and SPLUMA. The latter part of the mandate refers to the Water Services Development Plan to be prepared on the same spatial scale as the municipal SDF and land use scheme.

Source: Own construction (2018) adopted from South Africa (1998a)

Provincial level: Several of South Africa's provinces have Water and Sanitation Master Plans in place to guide and align various infrastructure projects from national level down to local municipal level. However, there are no legislative requirements for the preparation and implementation of Provincial Water and Sanitation Master Plans.

Sub-catchment/regional level: The National Water Act allows for the development of sub-catchment management strategies, also referred to as reconciliation strategies, in the case where catchments within a WMA vary markedly. The content should be similar to that of its larger catchment, but the level of detail should improve at this planning scale.

Municipal level: Section 13 of the Water Services Act requires all WSAs to prepare a Water Services Development Plan (WSDP) as its primary water service planning instrument to be updated and reviewed every five years. The WSDP must aim to integrate technical, social, institutional, financial and environmental planning, ultimately forming part of the integrated development planning process. Based on the prescribed content, Table 4-3 summarises the relevance of a WSDP to municipal spatial planning and land use management tools.

Table 4-3: Section 13 of Act no 108 of 1997

Every WSDP must contain detail...	Relevance to spatial planning and land use management
(a)...of the physical attributes of the area to which it applies.	- Physical attributes should include, amongst others, all built-up areas and land uses as identified in the municipal land use scheme. Information presented in WSDP should also be included in the process of developing the SDF and land use scheme.
(b)...of the size and distribution of the population within that area.	- Often one would find that population distribution figures represented in WSDPs and figures represented in SDFs differ by a few thousand. Alignment of population figures and their distribution is critical in terms of target setting for municipal services.
(c)...of a timeframe for the plan, including the implementation programme for the following five years.	- The SDF is required to include a 5-, 10- and 20-year population projection and define where this growth will take place. This SDF growth projection should inform the WSDP implementation programme and vice versa.
(d)...of existing water services.	- The WSDP should provide spatial and non-spatial information on all existing water services and physical infrastructure. One of the major shortcomings to date is that very few, if any of existing SDFs, contain information related to capacity or development potential of existing water services and their physical infrastructure.
(g)...of the number and location of persons within the area who are not being provided with a basic water supply and basic sanitation.	- Knowing the number and location of persons not being provided with a basic water supply and basic sanitation is critical for spatial planners as the SDF is required to provide estimates on infrastructure requirements. - Furthermore, the SDF should also assist the WSA in determining whether or not these people should even reside in the area.
(h)...regarding the future provision of water services and water for industrial use and the future disposal of industrial effluent, including- (iii) the proposed infrastructure necessary; (iv) the water sources to be used and the quantity of water to be obtained from and discharged into each source; (v) the estimated capital and operating costs of those water services and the financial arrangements for funding those water services, including the tariff structures; (vii) the operation, maintenance, repair and replacement of existing and future infrastructure.	- Item (iii) should be informed by the SDF's growth projections as well as the spatial proposals as to where this growth will be accommodated (spatially). The WSDP should then determine the infrastructure requirement necessary to service these future growth areas. The same goes for backlogs in services. - Item (iv) should look at alternative water supply options such as greywater reuse, rainwater harvesting, and stormwater harvesting. Information contained in the WSDP should inform the municipal SDF and the land use scheme as far as possible, e.g. protective buffer zone around boreholes or impoundment areas. - Item (v) should inform the municipal SDF's capital investment framework as per section 21 (n) of SPLUMA - Item (vii) generally refers to information contained in the municipal asset management plan. Once again, the requirements of all future water infrastructure should be informed by the municipality's SDF, provided that it assigns designated future growth areas.
(i)...of the number and location of persons to whom water services cannot be provided within the next five terms, setting out— (ii) the time frame within which it may reasonably be expected that a basic water supply and basic sanitation will be provided to those persons.	- This information is directly applicable to the development and implementation of a municipal SDF and is therefore critical to be included in the municipal SDF.
(j)...of existing and proposed water conservation, recycling and environmental protection measures.	- The WSDP measures for water conservation, recycling, and environmental protection should as far as possible include a spatial reference, e.g. environmental protection measures should be priorities in all wetland and wetland buffer zones.

Source: Own Construction (2018) adopted from South Africa (1996)

Unlike the previous strategies and plans, the WSDP is prepared on the same spatial scale as the municipal SDF and the municipal land use scheme. Based on the summary of tables, the WSDP is also most relevant to municipal spatial planning and land use management.

4.2.3.2 Strategic planning for environmental resources

National level: The Biodiversity Act requires the Minister to publish a National Biodiversity Framework (NBF) in terms of Section 28(2) (DEA, 2009). The NBF should aim to co-ordinate and align the efforts of organisations and individuals involved in conserving and managing South Africa's biodiversity outside of protected areas. Based on the prescribed content, Table 4-4 summarises the relevance of an NBF to municipal spatial planning and land use management tools.

Table 4-4: Section 39 of Act no. 10 of 2004

National biodiversity framework must...	Relevance to spatial planning and land use management
(a)...provide for an integrated, co-ordinated and uniform approach to biodiversity management by organs of state in all spheres of government, non-governmental organisations, the private sector, local communities, other stakeholders and the public;	- This includes all local governments responsible for municipal planning and water services.
(c)...identify priority areas for conservation action and the establishment of protected areas;	- This includes amongst others threatened ecosystems, priority areas for management and restoration of ecosystems, and areas where more detailed assessment and planning is required. These priority areas have spatial references and should be included in both the municipal SDF and the land use scheme if relevant to the local municipality.
(2)... may determine norms and standards for provincial and municipal environmental conservation plans.	- Environmental conservation plans are not bound to administrative boundaries; they can cross boundaries or only apply to small areas of land. Nevertheless, these plans, and the norms and standards as they relate to land use management, should be included in municipal SDFs and land use schemes.

Source: Own Construction (2018) adopted from South Africa (2004a)

The National Environmental Management Act also requires certain national departments and all provinces to develop either an Environmental Implementation Plan (EIP) (Schedule 1), or an Environmental Management Plan (EMP) (Schedule 2) or a Consolidated Environmental Implementation and Management Plan (CEIMP) (if listed in Schedule 1 and 2). Sections 13 and 14 of NEMA provide an outline of the contents of an EIP and an EMP. However, a review of the prescribed content and of existing EIPs and EMPs indicates that generally there is no spatial reference as to where these policies, plans and programmes will be implemented. Consequently, it is difficult to align EIMs and EMPs to municipal spatial planning and land use management instruments.

Provincial level: The NBF states that all provinces must develop and adopt a provincial Spatial Biodiversity Plan that identifies critical biodiversity areas (CBA) and ecological support areas (ESA) through a process of systematic biodiversity assessment. Once identified, the Provincial Spatial Biodiversity Plan must assign land use management guidelines for all CBAs and ESAs.

Sub-catchment/regional level: CBAs and ESAs identified in the Provincial Spatial Biodiversity Plans call for a finer scale biodiversity plan, which is the Bioregional Plan. The purpose of a bioregional plan is, amongst others, to inform land-use planning and environmental authorisation. Although there is no legislated content for the preparation and implementation of Bioregional Plans, guidelines do exist (South Africa, 2008). A review of the proposed content of a bioregional plan makes it evident that they are without doubt entirely relevant to both municipal SDFs and municipal LUS.

Municipal level: Similar to that of a Provincial Spatial Biodiversity Plan, Section 24(3) of the National Environmental Management Act mandates the development of Environmental Management Frameworks (EMFs) on district or municipal level to highlight “environmentally sensitive areas, and areas where certain land uses are most compatible or incompatible with environmental opportunities and constraints in the landscape” (Driver *et al.*, 2011:48). Based on the prescribed content, Table 4-5 summarises the relevance of a Municipal EMF to municipal spatial planning and land use management tools.

Table 4-5: Section 24(3) of Act No. 107 of 1998

An EMF must –	Relevance to spatial planning and land use management
(d)...state the conservation status and the (e) environmental management priorities of the area	- The spatial data, that delineate areas with conservation status and environmental management priorities must be included in the SDF to inform the municipality's growth management strategy (away from such areas) and its future spatial proposals.
(f)...indicate the kind of developments or land uses that would have a significant impact on those attributes and those that would not; (g) be undesirable in the area or in specific parts of the area.	- It should become a mandatory practice that all land use schemes include the land use management guidelines as proposed by the EMF – specifically as it relates to CBAs and ESA.

Source: Own Construction (2018) adopted form South Africa (1998b)

EMFs are spatial in nature and are legally binding in terms of Regulation 72 of the EIA regulations.

Area specific: The highest degree or level of protection that can be granted to a piece of land, is to declare the area as protected in terms of the Protected Areas Act.

Once the area has been declared as a protected area, a protected area management plan must be submitted to the MEC for approval. Based on the prescribed content, Table 4-6 summarises the relevance of a Protected Areas Management Plan to municipal spatial planning and land use management tools.

Table 4-6: Section 41(2) of Act 57 of 2003

A Protected Areas Management Plan must contain at least...	Relevance to spatial planning and land use management
(a)... a zoning of the area indicating what activities may take place in different sections of the area, and the conservation objectives of those sections, provided that in a marine protected area, the zoning must not conflict with a zoning in terms of section 48A(2)(a)	The delineation of the protected areas should be included in the future spatial proposals of the SDF, while the zonings of the protected areas management plans must be included in the municipal land use scheme.

Source: Own Construction (2018) adopted from the Protected Areas Act 2003

While the declaration of land as protected areas is a powerful tool for conserving biodiversity, Environmental Impact Assessments (EIAs) also allow for the protection of ecologically sensitive areas (DEA, 2015:45). However, the EIA process is generally conducted on a case-by-case basis has been severely criticised in the past for the levels of backlogs in assessing applications and long timeframes for approval, as well as with difficulties in addressing cumulative impacts (Middleton *et al.*, 2011:19).

In theory, these plans must align to national, provincial and local governments' spatial plans. However, in practice it is rarely the case, hence the unsustainable trajectory of unsustainable levels of services delivery, high water pollution, and especially high demand patterns. In an attempt to address these national concerns, the DWS has several organisations involved in its water business, one of which should be placed under the spotlight, i.e. the South Africa Water Research Commission (WRC) which undertakes water-related research activities for the DWS. Section 4.3 to follow, provides a literature review on the concept of water sensitivity and how it relates to South Africa.

4.3 Opportunity for change – water sensitivity

“The 21st century marks the first point in recorded history when the proportion of the world’s population living in urban environments has surpassed those residing in the rural environment, making cities a critical focal point for realising sustainable practices” (Brown *et al.*, 2008:1). The current fabric of cities and settlements is largely the result of past development and land use decisions (Serrao-Neumann *et al.*, 2017). These decisions were followed by engineering solutions such as water, sanitation and stormwater networks, which focused on getting resources in and out of the city as quickly as possible.

“This perspective on dealing with water services prioritised quantity management (flow), with little or no emphasis on the preservation of the natural environment” (Armitage *et al.*, 2014). The impact of such development spreads far beyond the actual extent of developed areas.

Chapter 3, Section 3.3.2 highlighted that the concept of IWRM was officially introduced to the global audience at the 1977 International Conference on Water. Yet, not much came of it until the 1992 International Conference on Water and the Environment, which re-affirmed the need for a holistic approach to water resources management by linking social, economic, and land development with the protection of natural ecosystems. More recently, the Global Water Partnership defined IWRM as “the process which promotes the coordinated development and management of water, land, and related resources, to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (GWP, 2000:22). The definition explicitly refers to the integrated management of land and water, as land use and land cover influence the physical distribution and quality of water and must be considered in the overall planning and management of the water resources. Since the introduction of IUWM a culture-change in urban water resources management has taken place in many countries.

This culture-change has facilitated a movement towards holistic stormwater management, changing the perception that stormwater is not a “nuisance that should be removed” but rather a “resource that should be utilised” (Ashley *et al.*, 2013). Several terms, including Sustainable Urban Drainage Systems (SUDS), Low Impact Development (LID), Water Sensitive Urban Design (WSUD), and Green Infrastructure (GI) have made their way into the urban development scene (Fletcher *et al.*, 2015:526-532). Table 4-7 provides a summary of the various concepts that have emerged globally in support of IUWM.

Table 4-7: Supporting concepts for IUWM

Concept	Country	Description
“Low Impact Development (LID)	USA	“Describes planning and design approaches for stormwater runoff management with sustainable stormwater management practices”.
Green Infrastructure (GI)	USA	“Similar to LID, describes stormwater management approaches and practices to reduce or eliminate runoff through onsite infiltration, evaporation, and/or reuse of rainwater.”
Sustainable Urban Stormwater Management (SUDS)	UK	“Describes measures for sustainable stormwater management.”
Best Management Practices (BMP)	Europe	“Describes measures for sustainable stormwater management.”
Decentralised Rainwater / Stormwater Management	Germany	“Describes measures and techniques for rainwater harvesting and stormwater management.”

Integrated Urban Resource Water Management (IURWM)	Global	“Describes an integrated approach to manage urban water (not only stormwater).”
Water Sensitive Urban Design (WSUD)	Australia	“Describes an approach that aims to integrate water management, particularly decentralised stormwater management, into urban design.”

Source: Fletcher *et al.* (2015:526-532)

4.3.1 South African Guidelines for Sustainable Urban Drainage Systems

In 2013, the WRC published “The South African Guidelines for Sustainable Drainage Systems” which emanated from a project entitled 'Alternative technologies for stormwater management' (WRC Project No. K5/1826) (Armitage *et al.*, 2013:ii). The guideline focuses primarily on the Australian concept of SuDS as a stormwater management solution in South Africa's urban areas and the effect of urbanisation on both stormwater quality and quantity. The guideline document aimed to introduce SuDS into South Africa's urban environment, to reduce stormwater quantity flow rate and volume, improve stormwater quality, and enhance amenity and the maintenance of biodiversity (Ibid.:3).

The SuDS guideline provides detailed information on calculations and technical illustrations (see Figure 4-4) on twelve families of SuDS options designed to maintain pre-development conditions. These include Bio-retention areas; Detention ponds; Filter strips; Green roofs; Infiltration trenches; Multi-purpose detention ponds; Permeable paving; Rainwater harvesting; Retention ponds; Wetlands and Soakaways (Ibid.: 22-57). The SuDS Guideline suggests that a SuDS will function best when implemented in a series of treatment trains starting with good housing keeping, followed by source controls, local controls, regional controls and finally discharging treated stormwater back to receiving waters (Ibid.:4-5) (see Figure 4-5).



Typical SuDS design drawings

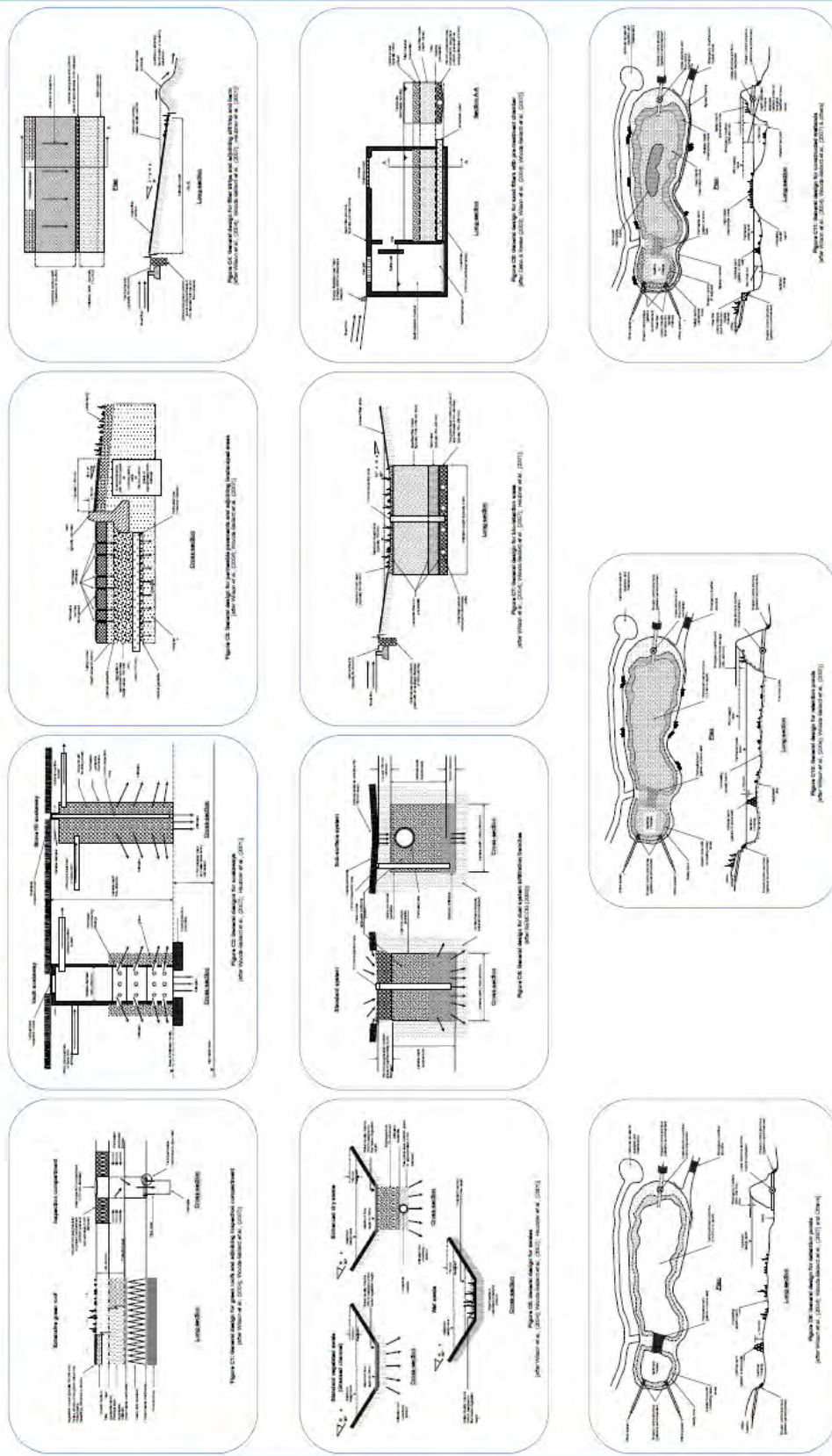


Figure 4-4: Typical SUDS design drawings
Source: Armitage *et al.* (2014)

K5/1826: Alternative technology for stormwater management
www.wsud.co.za

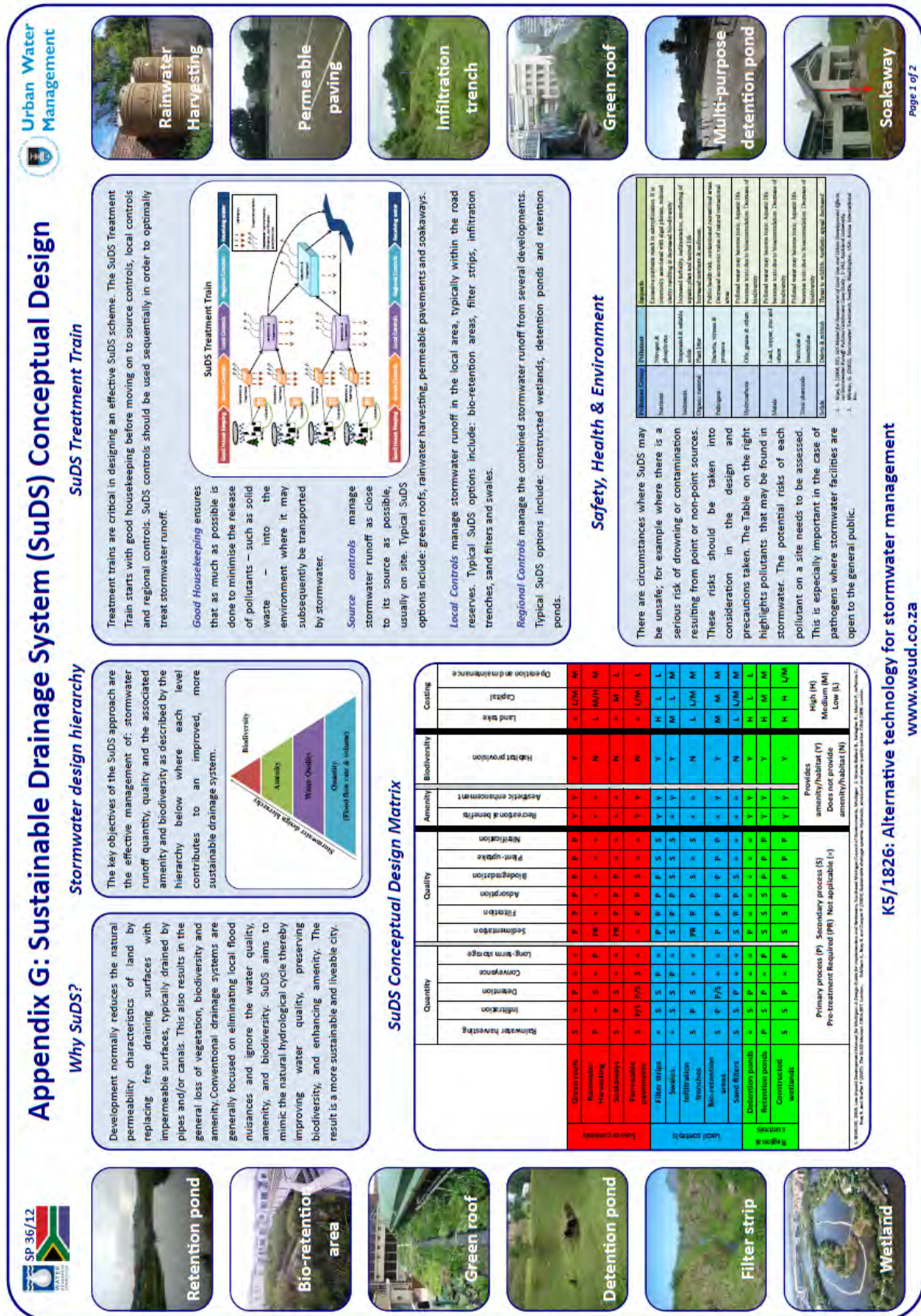


Figure 4-5: SuDS Conceptual design
Source: Armitage *et al.* (2014)

The following section highlights certain aspects of SuDS selection for source control, local controls, and regional controls, which should be considered within the broader spatial planning and land use management framework.

4.3.1.1 Source Controls

SuDS selection for source control treatment includes green roofs; rainwater harvesting; soakaways, and permeable pavements. These SuDS source controls treat stormwater as close to its source as possible, decreasing both stormwater runoff rate and volume, gradually discharging stormwater to the surrounding soils, and facilitating relatively high rates of groundwater recharge (Armitage *et al.*, (2014:5). In selecting SuDS source controls, the following should be considered as it applies to land characteristics and land use management (Ibid.:22-34).

- Green roofs and walls are typically associated with the goal to reduce the rate and volume of stormwater runoff as it interacts with a vegetated roof or wall. Green roofs are most effective on large roof surfaces, typically associated with industrial, commercial, and business buildings, and blocks of flats. Green roofs can be constructed on flat and gently sloped (between 0°-20°) roofs and weigh more or less between 40 and 60 kg/m².
- Rainwater harvesting systems can be installed to almost all roofs and impervious surfaces, including parking bays. It is most effective on a corrugated iron, pitched roof typically associated with modern buildings. Similar to rainwater harvesting, stormwater harvesting refers to the collection and storing of runoff from large impermeable surfaces in underground storage tanks. With limited treatment, harvested rainwater and stormwater can be used for non-potable purposes such as gardening and toilet flushing.
- Soakaways operate on a small scale, typically within a space not bigger than 1 000 m², which may include residential buildings or offices. Multiple soakaways can be linked to drain larger areas such as parking lots and motor highways as large as 100 000 m². Soakaways do not function well when constructed on steep slopes and in loose or unstable areas. Sub-drain piping systems must be utilised when soakaways are implemented in very fine silt and clay stratum because of the low infiltration rates. They should be constructed at least 1.5 m above the groundwater table to prevent groundwater contamination.
- Permeable pavements are most suitable for installation areas such as residential driveways, parking bays, private roads, public service roads, fire engine lanes, industrial storage and loading areas, bike pathways, walkways, terraces, and around swimming pools. However, the implementation of permeable pavements is generally limited to sites with slopes of less than 5% and is normally not suitable for high traffic volumes and speeds greater than about 50 km/hr, or for usage by heavy vehicles and/or high point loads.

4.3.1.2 Local Controls

If stormwater cannot be handled on site, the next link in the management train is local SuDS controls that attempt to manage all the stormwater generated in a local area (Armitage *et al.*, 2013:5).

Where stormwater is to be conveyed from one place to another, natural channels should be used instead of pipes and concrete-lined canals, which speed up the flow and provide little water quality benefits. SuDS selection for local control treatment includes filtered strips, swales, infiltration trenches, bio retention areas, and sand filters. In selecting SuDS local controls, the following should be considered as it applies to land characteristics and land use management (Ibid.: 22-34):

- Filtered strip and swales are both vegetated or grass lined areas of land. Swales, however, have a distinctive flat and sloped side and have larger storage capacity than filtered strips (Ibid.:35-40). Nevertheless, both reduce high runoff volumes and peak stormwater flows. Filtered strips are commonly used along stream banks as vegetated buffer systems, and also downstream from agricultural land to intercept and infiltrate stormwater runoff. Filtered swales are generally suitable for road medians, road kerbs in low-density residential areas, verges, car parking runoff areas, parks and recreational environments (Armitage *et al.*, 2013:37-38). They can also be effectively used in low-density development and in public open spaces, and normally serve areas smaller than 20 000 m² (Ibid.: 35-36). As a rule of thumb, the initial sizing of the specified filter strip should allow for an infiltration area approximately twice that of the contributing impervious stormwater runoff surface, or be at least be as long and wide (Ibid.).
- Infiltration trenches and bio-retention areas both decrease the frequency and extent of flooding due to their ability to increase stormwater infiltration and groundwater recharge (Armitage *et al.*, 2013:40). They are also very effective in removing suspended particulates from stormwater. Infiltration trenches have relatively narrow cross sections ranging between 1 000 and 2 000 mm, which makes them suitable in urban areas or adjacent to impervious areas such as roads, footpaths, parking lots, and other hardened areas. Bio-retention areas are applicable for managing stormwater runoff on many sites, e.g. between residential plots, parking lots, adjoining roadways, and within large landscaped impervious areas (Armitage *et al.*, 2013:42).
- Sand filters are the most effective SuDS for water quality improvement and can be installed in conjunction with land uses with impervious areas of less than 8 000 m² (Armitage *et al.*, 2013:45). Sand filters are most commonly used in arid regions with high evaporation rates, limited rainfall, and where there is a significant requirement to protect groundwater resources (Ibid.:46).

4.3.1.3 Regional Controls

Regional SuDS controls represent the last line of defence for the management of stormwater before it is discharged to the receiving waters (Armitage *et al.*, 2013:5). SuDS selection for regional control treatment includes detention ponds, retention ponds, and constructed wetlands. These SuDSs require large areas of land and engineered structures that regulate the intake and discharge of stormwater. In selecting SuDSs for regional controls, the following should be considered as it applies to land characteristics and land use management (Ibid.:22-34).

- Detention ponds are temporary storage facilities that are ordinarily dry but are designed in such a manner that they are able to store stormwater runoff for short periods of time (Ibid.:49). Detention ponds can be integrated into sports facilities such as tennis courts

and skate parks that can be flooded during a storm (Ibid.). A detention pond typically requires a surface area of at least 2% of its contribution impervious area (Ibid.:50).

- Retention ponds have a permanent pool of water and provide a medium to high pollutant removal capacity, making water in a retention pond reusable for irrigation and secondary domestic purposes where the water quality is acceptable (Armitage *et al.*, 2013:52).
- Constructed wetlands are man-made systems designed to mimic the natural systems in areas where they would not usually be found (Armitage *et al.*, 2013:54). They are most often to be found in flat areas, serving catchments larger than 10 ha, and are particularly useful in attenuating stormwater flood peaks and ‘polishing’ the runoff from residential areas. Constructed wetlands can also be used to harvest rainwater, and to function as an alternative treatment solution for wastewater. If constructed for the purpose of treating wastewater, the size of the constructed wetland should be approximately 3 to 6 m² per person. It can also take up to two years to reach maximum treatment efficiency.

4.3.2 Water Sensitive Urban Design for South Africa: Framework and Guidelines

Following the 2013 SuSD Guideline publication, the WRC published another document entitled “Water Sensitive Urban Design for South Africa: Framework and Guidelines” in September 2014 (Armitage *et al.*, 2014). The publication emanated from a project entitled Water Sensitive Urban Design (WSUD) for improving water resource protection / conservation and re-use in urban landscapes (WRC Project No. K5/2071). It consists of two parts – a framework (part 1) and a guideline (part 2).

The framework (Part 1) highlights several key issues and challenges including: “South Africa is severely constrained by low rainfall, limited underground aquifers, and reliance on significant water transfers from neighbouring countries...; wastewater is being generated at an alarming rate and often water treatment is compromised, leading to increased pollution of surface and ground water...; the deteriorating quantity and quality of South Africa’s water resources is particularly problematic as these ecosystems affect the reliable production of food and energy, all of which are critically important for the country’s social and economic development...; people have a general disregard for the value of water – both economic and socio-cultural...; fragmented “silo-management” of different aspects of the urban water cycle occurs, in part, because of allocation of different responsibilities to different municipal departments...; and, it will be difficult for the government to implement “green” projects when basic services do not exist, unless these are accomplished simultaneously” (Ibid.:2).

In response to the above challenges the Framework (Part 1) adopted the aspirational concept of a Water Sensitive City (WSC), pioneered by Brown *et al.* (2008) at the 11th International Conference on Drainage in 2008.

To date, there is no universally accepted definition for a Water Sensitive City, yet the Cooperative Research Centre for Water Sensitive Cities (CRCWSC) defines it as “a city that interacts with the urban hydrological cycle in ways that provide the water security essential for economic prosperity by efficiently using a diversity of water resources available; enhances and protects the health of watercourses and wetlands; mitigate flood risk and damage; and create public spaces that harvest, clean and recycle water” (CRCWSC, 2019).

A transitioning framework which emanated from a six-year social research programme developed by Brown *et al.* (2008:5) clarifies the “hydrosocial contracts currently operating across cities and sets a roadmap towards transitioning into a water sensitive city. The roadmap depicts a typology of six city-states, namely ‘water supply city’, the ‘sewered city’ the ‘drained city’ the ‘waterway city’, the ‘water cycle city’, and ultimately the ‘water sensitive city’” (see Figure 4-6).

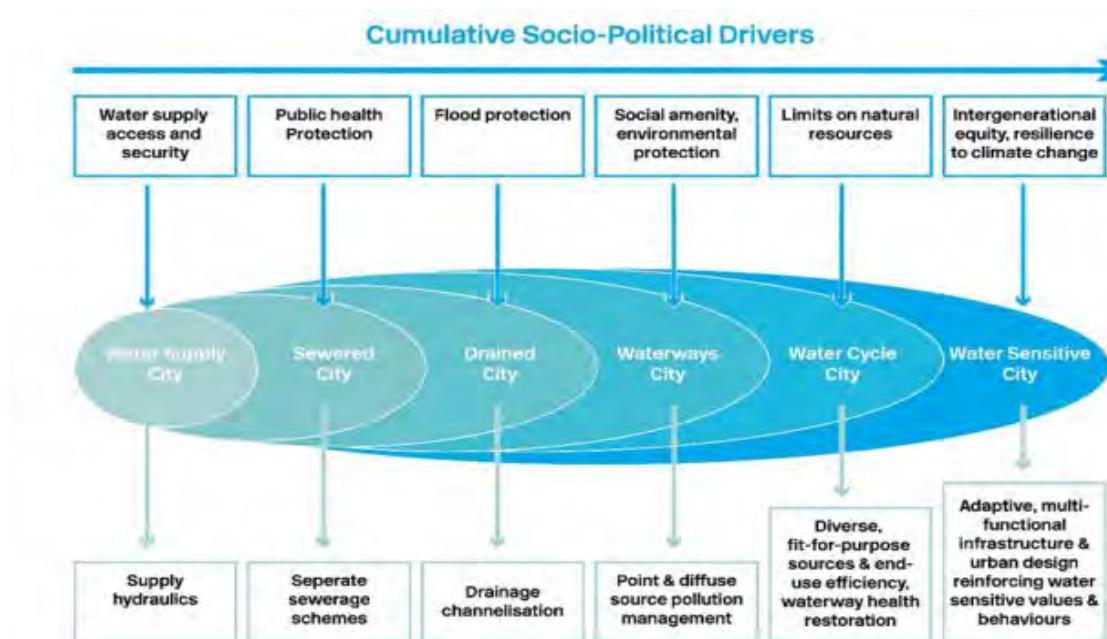


Figure 4-6: Roadmap towards WSC

Source: Brown *et al.* (2008:2)

The transitioning framework takes into consideration the “temporal, ideological and technological context that cities transition through when moving between different management paradigms and is sensitive to other influencing conceptual variables such as city-specific history, ecologies, geographies and socio-political dynamics” (Ibid.:2).

According to Brown *et al.* (2008:5) “not one city can be directly compared to another as each city is in its own transitioning stage due to differing socio-political and biophysical conditions”. It is widely acknowledged that the process of becoming a Water Sensitive City will involve “a transition, driven by radical shifts in the structures, cultures, and practices, underpinned by urban planning and water resource management.

It calls for integrated development planning between all spheres of government and many diverse stakeholders to enable change that would result in a more sustainable system, notably by overcoming resistant cultures, structures, and practices that are 'locked in' to a current unsustainable path. Facilitating transitions is not easy. It requires dedicated attention to disrupt the dominant paradigm (in this case, urban planning practices) so that the emerging alternative of a Water Sensitive Cities can become influential" (Ibid, 2008).

Wong & Brown (2008:4) refer to "the three "pillars of practice" of a Water Sensitive City that must be seamlessly integrated into the built environment". The pillars include 'Cities as water supply catchments', 'Cities providing ecosystem services', and 'Cities as Water Sensitive Communities' (Wong & Brown, 2009: 676-679).

Cities as water supply catchments – "Most cities are almost exclusively dependent on water supply from a single source where water is extracted either from rivers or dams, and treated and distributed from a centralised water treatment plant to the city. As a response to water sensitivity, cities must break their dependency on a single water source and access a diversity of water sources underpinned by centralised and decentralised infrastructure" (Ibid.). According to Wong & Brown (2009:677) the following components allow for cities to become catchments:

- "Cities should utilise groundwater, harvest stormwater and rainwater, recycled wastewater (greywater and blackwater), and desalinated water;
- Cities should develop large-scale indirect potable reuse schemes linked to regional reservoirs (treated recycled water returned to water supply scheme); and,
- Cities should install a secondary supply pipeline (third-pipeline system or dual pipeline) to distribute partially treated stormwater and recycled wastewater for non-potable water uses such as toilet flushing, laundry, garden watering, and open space irrigation" (Wong & Brown 2009: 676-677).

Cities providing ecosystem services – "The value of urban open spaces and landscapes must be determined in terms of their 'ecological functions' that capture the essence of sustainable water management, microclimate influences, facilitation of carbon sinks and use for food production. Protecting the environment from polluted stormwater is one of the primary objectives of sustainable water resources management, which can be achieved through land use management and by implementing SuDS such as constructed wetlands and bio-retention systems on a range of spatial scales". Water sensitive cities call for new principles in spatial planning in developed areas through higher density development, less built coverage, and greater utilisation of public open spaces for multiple functions. Initiatives for creating cities that provide ecosystem services include:

- freshwater ecosystem priority areas should be protected from development through buffer zones and waterway health management initiatives (rehabilitation strategies);
- Ecological infrastructure should be enhanced and better utilised through urban landscape design of large open spaces and connected blue-green corridors that have both an aesthetic and functional role;
- Cities should limit the expansion of their built footprints through strict development boundaries and by promoting higher densities and less floor coverage (growth management or densification strategies and development controls” (Wong & Brown 2009:678).

Cities as Water Sensitive Communities – “New technologies must be socially embedded into the local institutional context, else their development in isolation will be insufficient to ensure their successful implementation in practice. New governance approaches towards policy, legislative and regulatory frameworks that guide the activities, roles, and responsibilities of local governments, water utilities and government agencies, households and communities must be informed by the principles of water sensitivity. Initiatives for creating water sensitive communities include:

- Water sensitivity should feature in government and municipal policies;
- Planning provisions should address water sensitivity, e.g. set specific water quality and quantity targets to be regulated through municipal bylaws; and
- Water conservation and demand management strategies should be implemented through adjusted tariff structure (although not entirely related to spatial planning” (Wong & Brown 2009:678-679).

Armitage *et al.* (2014:19) identified the need to change the internationally accepted term “Water Sensitive City” to “Water Sensitive Settlements” (WSS), as settlements are broadly understood as comprising a concentration of people within a specific area (non-urban but densely populated rural settlement areas) serviced by some form of public infrastructure (Ibid.). Considering South Africa’s history and unique settlement types, the framework suggested that South Africa should adopt a context-specific roadmap towards WSS as illustrated in Figure 4-7.

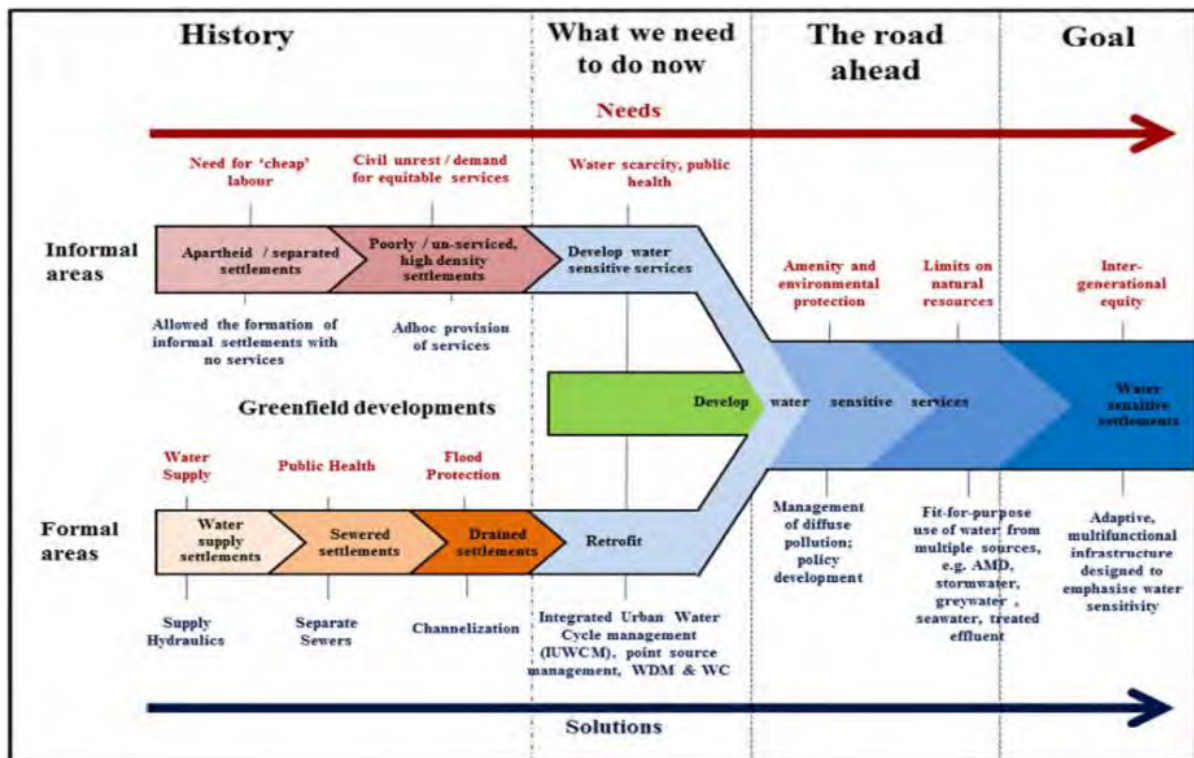


Figure 4-7: South Africa's roadmap towards WSS

Source: Armitage *et al.* (2014:25)

South Africa's roadmap towards WSS identified formal areas as drained settlements, and informal areas as poorly/un-serviced high-density settlements. In achieving the ultimate goal of WSS, the framework suggests that formal areas will have to retrofit existing infrastructure and focus on Integrated Urban Water Cycle Management, point source management, water demand management, and water conservation. A leapfrog approach towards water sensitive services (alternative solutions) is suggested in poorly/un-serviced informal settlements.

The framework highlights that in achieving WSS three components must be considered in an integrated manner, that is

- i) Water Sensitive Urban Design (WSUD);
- ii) Water Sensitive Urban Planning (WSUP); and
- iii) Water Sensitive Urban Management (WSUM) (see Figure 4-8).

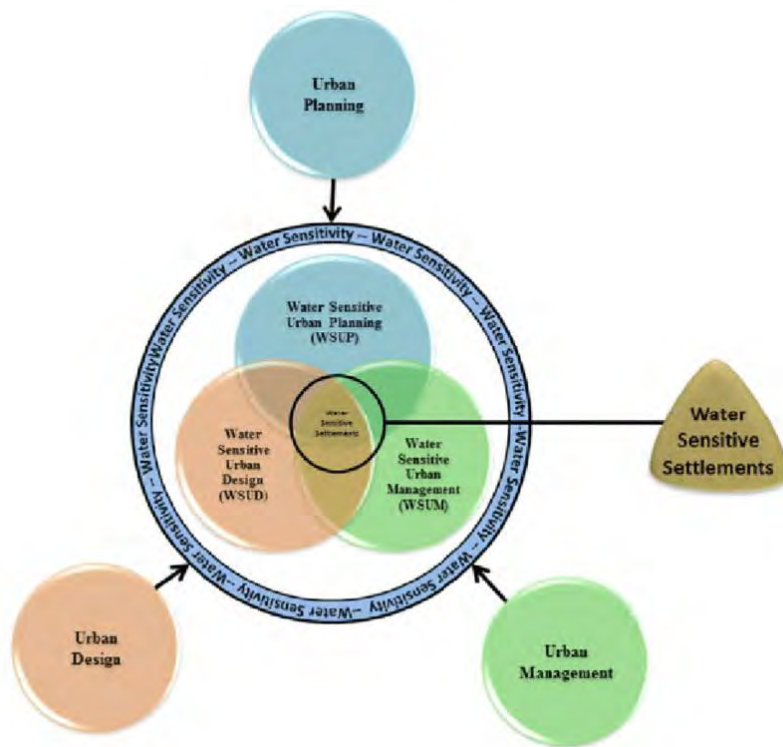


Figure 4-8: The integration of WSUD, WSUP and WSUM towards WSS

Source: Armitage *et al.* (2014:19)

While the Framework (Part 1) identified three components of WSS, the Guidelines (Part 2) focused on providing detail information on the WSUD component as the other two, WSUP and WSUM, were beyond the scope of the work at the time. Nevertheless, the Guideline (Part 2) made the following proposals for achieving WSS:

- Stormwater management – settlements should take a SuDS approach, which incorporates elements such as the enhancement of amenity and biodiversity, and flood mitigation (see SuDS Guideline).
- Sanitation / wastewater minimisation – settlements should improve effluent quality and more readily use treated wastewater / recycled water for non-potable reuses.
- Groundwater management – Settlements should investigate the potential for artificial recharge and utilise groundwater if feasible.
- Sustainable water supply options – Settlements should have strict water conservation and water demand management (WCWDM) policies in place, reduce their volume of NRW, and include alternative water sources, e.g. rainwater / stormwater harvesting as a water supply source.

Based on South Africa's context specific issues and opportunities, the Framework (Part 1) defines the philosophy of water sensitivity in South Africa as "... the management of the country's urban water resources through the integration of the various disciplines of engineering, social and environmental sciences – whilst acknowledging that: South Africa is a water scarce country; access to adequate potable water is a basic human right; the management of water should be based on participatory approach; water should be recognised as an economic good; and water is a finite and vulnerable resource, essential to sustaining all life and supporting development and the environment at large" (Armitage *et al.*, 2014:ii).

4.3.3 Contextualising WRC publications and future research opportunities

The South African Guidelines for Sustainable Drainage Systems (Armitage *et al.*, 2013) and the Water Sensitive Urban Design for South Africa: Framework and Guideline (Armitage *et al.*, 2014) set the foundation for future research that revolves around the theme of water sensitive development in South Africa.

However, according to Armitage *et al.*, (2014:41) "there is unrealised potential for more extensive co-ordination – which could be facilitated by urban and strategic planning fora". However, information is still limited as to exactly how spatial planning and land use management as it relates to the component of Water Sensitive Urban Planning can give effect to achieving Water Sensitive Settlements. Figure 4-9 provides a schematic illustration of the relationship between the two WRC publications and where this study fits into the research theme.

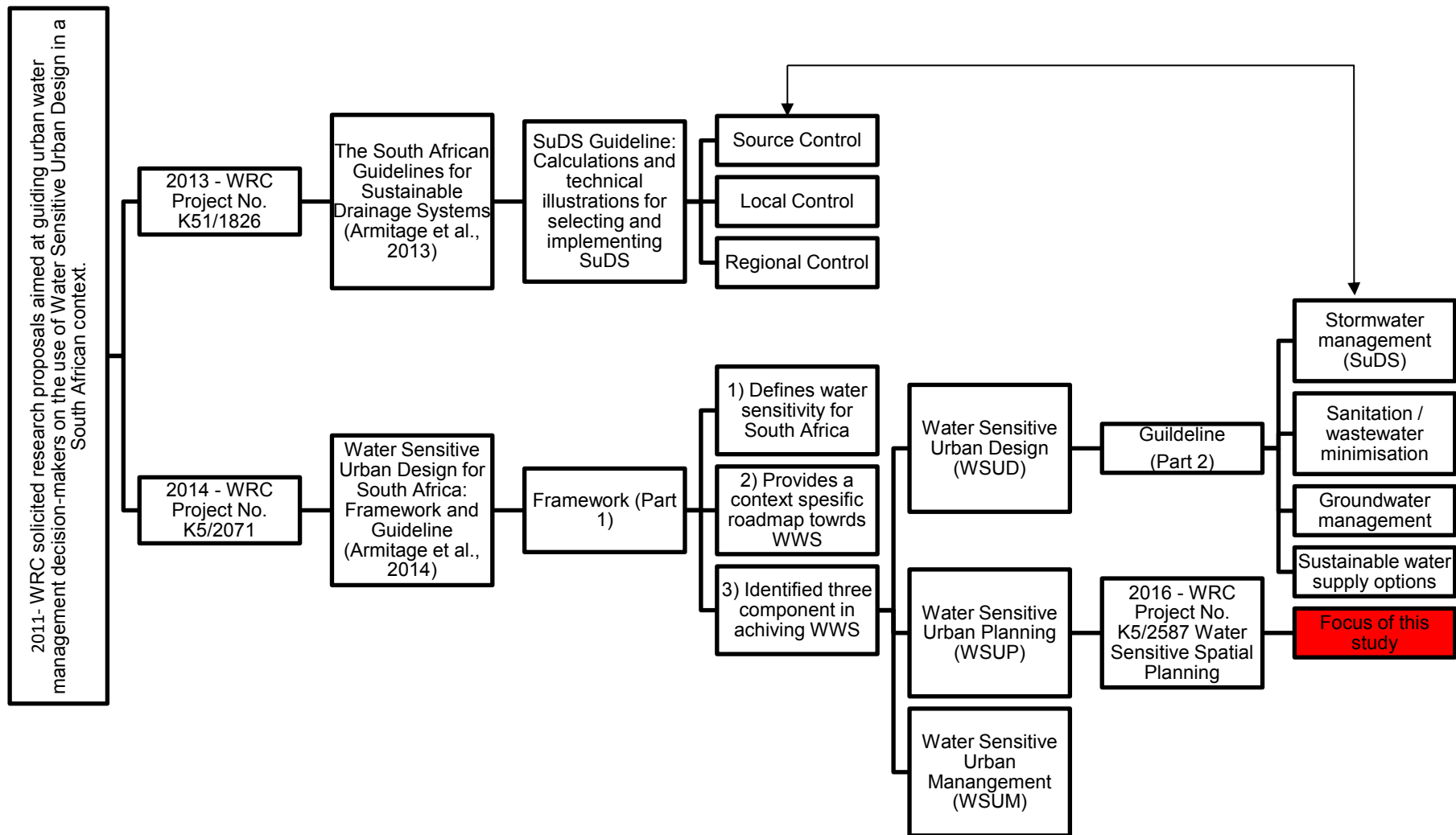


Figure 4-9: Contextualising WRC publications and future research opportunities

Source: Own Construction (2018)

4.4 Water Sensitive Spatial Planning

Spatial planning and land use management in South Africa takes place within the legislative framework as mandated by the Spatial Planning and Land Use Management Act No 16 of 2013. As mentioned in Section 3.6.2, the primary motivation for the enactment of this ‘new’ planning law was based on the need for a new planning regime – one that replaces the apartheid-era laws with a coherent legislative system designed to spatially transform the country in its democratic era. Such transformation should address spatial justice, spatial sustainability, efficiency, spatial resilience, and good administration, all of which should take place within the proposed WSS framework.

SPLUMA provides for the preparation and implementation of National, Provincial, Regional and Municipal Spatial Development Frameworks (SDFs), as well as a Municipal Land Use Scheme (LUS) (South Africa, 2013). An SDF is considered to be a strategic planning policy instrument which needs to guide future planning and development decisions spatially, across all sectors of government. A land use scheme is a planning tool that allows or restricts certain types of land uses to certain geographic areas. The SPLUMA declares that a municipal land use scheme adopted in terms of Section 24 of Act 16 of 2013 has the force of law and all land owners and users of land, including a municipality, a state-owned enterprise and organs of state within the municipal area are bound by the provision of such land use scheme.

Throughout the previous Chapters, the study indicated that land use (the activity) and land use decisions (where the activity takes place) have an impact on both water quantity (consumption) and quality (pollution and destruction of ecological resource). This study acknowledges that spatial planning and land use management also function within a hierarchy of spatial plans. The study deliberately chose to focus only on municipal level spatial planning as the decisions and regulations for land use, as addressed in the municipal SDF and the municipal LUS, will be directly responsible for water quantity and quality related implications.

4.4.1 Water Sensitive Spatial Development Frameworks

Sections 14, 16, 19 and 21 of the SPLUMA require the preparation and implementation of National, Provincial, Regional and Local municipal SDFs to adhere to their mandated requirements as set out in the Act (South Africa, 2013). At the time of writing, the DRDLR was in the process of developing the National SDF to give effect to South Africa’s NDP (South Africa, 2018). In June 2018, a draft National Spatial Development Framework was released for public comment.

In terms of water resources, the NSDF noted that cities and towns that support the national economy and large population concentrations already rely on water transfers from stressed catchment areas. Based on projections, the national water deficit could be between 2,7 and 3,8 billion m³/annum by 2030. This translates to a water supply and demand gap of 17%, if the interventions proposed in the Draft National Water Plan are not implemented (South Africa, 2018:44).

As for provincial governments, they need to prepare Growth and Development Strategies (GDS) to give effect to the NDP on a finer scale which should be spatially reflected in a Provincial SDF. A provincial SDF should also provide for a spatial expression of provincial sector plans and align district and municipal planning within the province (South Africa, 2013). Section 18(1) of the SPLUMA also allows for the development of regional SDFs to guide spatial planning, land development and land use management in any specific region of the Republic (Ibid.).

As for municipal planning, the IDP serves to provide strategic direction and alignment between all government spheres and sector departments on local municipal level. The municipal SDF serves to give spatial direction to the IDP and provide a common spatial agenda for sector plans. The aim of a SPLUMA compliant SDF is to provide an overview of the future spatial form of the municipality (10-20-year plan), and function as the primary tool to be used to decide if a change of land use rights should be permitted. SPLUMA also requires that a municipal SDF depict a spatial vision and design strategies to address physical, social and economic defects within the municipality (Ibid.).

Table 4-8 summarises how an SDF can give effect to WSS and align with water and environmental resource planning and management. Actual implementation thereof will be assessed throughout Chapter 5.

Table 4-8: Section 21 of Act 16 of 2013 - towards water sensitivity

An SDF must...	How to plan towards water sensitivity
(b)...must include a written and spatial representation of a five-year spatial development plan for the spatial form of the municipality;	The spatial development pattern consists of land uses. Land uses consume water and affect the quality thereof. Therefore, the decisions regarding the spatial patterns should consider the impact on water resource quality and quantity. To achieve cities / settlements that prove ecosystem services (Wong & Brown 2009) the future spatial form must: • protect freshwater ecosystem priority areas; • enhance ecological infrastructure through better utilisation of large open spaces and connected blue-green corridors; and, • limit the expansion of its built footprints and promote higher density developments. The proposed spatial form must also be informed and give effect to: • Section 39(3)(c) of Act no 10 of 2004 • Section 24(d)(e) of Act no 107 of 1998

(c)...include a longer-term spatial development vision statement for the municipal area which indicates a desired spatial growth and development pattern for the next 10 to 20 years;	This longer term spatial vision should incorporate the longer term outlook of water availability and incorporate the vision of a WSS as defined by Armitage <i>et al.</i>, (2014). The proposed spatial vision must also be informed and give effect to • Section 9(1)(c) of Act no 36 of 1998
(d)...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;	To achieve cities / settlements that prove ecosystem services (Wong & Brown 2009), structuring and restructuring elements must identify all: • areas of ecological importance which include rivers, wetlands, impoundment, estuaries, areas with high groundwater recharge potential, protected areas, CBA, ESA and all FEPAs as current and future structuring elements that will affect the future spatial form. In identifying these structuring and restructuring elements, the following should be included: • Section 9(1)(d) of Act no 36 of 1998 • Section 13(a)(b)(d) of Act no 108 of 1997 • Section 39(c) of Act no. 10 of 2004 • Section 24(3)(d)(e) of Act No. 107 of 1998 • Section 41(2)(a) of Act 57 of 2003 As for “where public and private investment will be prioritised and facilitated” the SDF must be informed by the following: • Section 13(c)(h)(ii)(iii) & (v) of Act no 108 of 1997
(e)...population growth estimates for the next five years; (f)...include estimates of the demand for housing units across different socio-economic categories and the planned location and density of future housing developments; (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;	Quantifying future water demand is essential. People and their use of the land that they will occupy will consume water. Sections (e) and (f) are coherent and therefore the SDF growth projection should also take into account where growth will likely take place and which socio-economic population group will need to be accommodated. Once this is determined the SDF can give effect to cities / settlements as water sensitive communities and water supply catchments (Wong & Brown 2009) by • setting realistic and water sensitive levels of services to be provided to future communities; • identifying alternative solutions for services provision (e.g. rainwater harvesting or largescale water reuse schemes) • setting specific water quality and quantity targets for specific spatial areas (WCWDM); • implementing a growth management strategy that promotes infill development as supposed to sprawl in areas where existing infrastructure can accommodate growth; and • targeting the areas identified to accommodate future growth for the implementation of a detailed WSUD plan. Areas identified as growth nodes should utilise groundwater, harvest stormwater and rainwater, recycled wastewater (greywater and blackwater), and desalinated water. In determining future growth, the following should be included: • Section 6(1)(b)(d) of Act no 36 of 1998 • Section 13(d)(h)(i) & (j) of Act no 108 of 1997
(g)...include estimates of economic activity and employment trends and locations in the municipal area for the next five years;	Future business and industrial nodes should be targeted for implementation of localised WSUD plans. These plans can translate into developing water resources and creating cities / settlements as water supply catchments by: • targeting all new business and industrial buildings and zones to implement rainwater harvesting and largescale wastewater reuse schemes;

	- installing a secondary supply pipeline (third-pipeline system or dual pipeline) to distribute partially treated stormwater and recycled wastewater for non-potable water uses such as toilet flushing, laundry, garden watering and open space irrigation; - targeting the areas identified to accommodate future business and industrial land uses for the implementation of a detailed WSUD plan – to improve water runoff.
(j)...identify the designated areas where a national or provincial inclusionary housing policy may be applicable; (k)...identify the designation of areas in the municipality where incremental upgrading approaches to development and regulation will be applicable;	Inclusionary housing should be prioritised in existing economic nodes close to existing services and possible job opportunities. First of all, the municipality has the right to dictate where this housing should be accommodated and determine the level of services to be provided to such areas. The SDF can give effect to cities / settlements providing ecosystem services and water sensitive communities by: - prioritising inclusionary housing in existing built-up areas, thereby protecting areas of ecological importance. In doing so, the SDF will also reduce the need for long extensive pipelines to sparsely populated rural settlements, reducing the UARL through a distribution network (reducing water losses); - setting realistic and water sensitive levels of services to be provided to all Inclusionary housing projects. - Areas where upgrading is required should be retrofitted with alternative technologies for water services.
(j)...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;	To achieve cities / settlements that prove ecosystem services (Wong & Brown 2009) a strategic assessment of environmental pressures and opportunities must identify all: - areas of ecological importance, which include rivers, wetlands, impoundment, estuaries, areas with high groundwater recharge potential, protected areas, CBA, ESA and all FEPAs as current and future structuring elements that will affect the future spatial form; - areas where land use and development in general have affected and in future may affect such areas; - make proposals for targeted rehabilitation strategies for areas of ecological importance; and - implement a growth management strategy to guide development away from areas of ecological importance. In identifying these structuring and restructuring elements, the following should be included: - Section 9(1)(d) of Act no 36 of 1998 - Section 13(a)(b)(d) of Act no 108 of 1997 - Section 39(c) of Act no. 10 of 2004 - Section 24(3)(d)(e)(f) of Act No. 107 of 1998 - Section 41(2)(a) of Act 57 of 2003
(l)...identify the designation of areas in which: more detailed local plans must be developed; shortened land use development procedures may be applicable, and land use schemes may be so amended;	To achieve cities / settlement that prove ecosystem services and water supply catchment (Wong & Brown 2009) the SDF should prioritise the following: - Densification of existing settlements is a key component of WSS. The SDF should therefore implement a densification strategy within existing built-up footprints and provide for shorter land development procedures. - The SDF should identify areas where land use is causing and will in future cause water quality issues. These areas should be targeted for the implementation of detailed WSUD plans. - The SDF should also identify areas of high land use with water quantity impact to be prioritised for WCWDM strategies.

	These spatial targeted approaches must be informed by the following: • Section 6(1)(h)(i) of Act no 36 of 1998 • Section 9(1)(a)(d) of Act no 36 of 1998 • Section 13(h)(iv) of Act no 108 of 1997 • Section 39(c) & (2) of Act no 10 of 2004
(m)...provide the spatial expression of the coordination, alignment, and integration of sectoral policies of all municipal departments;	The municipality should encourage the revision of sector plans based on the SDF spatial proposals. The SDF must also give effect to the WSDP, EMF, and CMS as prescribed by law. This critical principle should enforce cooperation between the planning department and the department responsible for water. Often this is not the case. A Spatial Development Framework (compiled by the planners) and the water services delivery plan contradict each other. The SDF should give a spatial expression of: • Section 13(1)(c)(f)(h)(i)(j) of Act no 36 of 1998 • Section 39(a) of Act no. 10 of 2004 • Section 24(3)(f) of Act No. 107 of 1998
(n)...determine a capital expenditure framework for the municipality's development programmes, depicted spatially; (p)... include an implementation plan comprised of: sectoral requirements, including budgets and resources for implementation, specification of institutional arrangements necessary for implementation; specification of implementation targets, including dates and monitoring indicators; specification, where necessary, of any arrangements for partnerships in the implementation process;	The capital investment framework must support the spatial proposals. More spatially efficient investment choices in both economic and basic infrastructure spending can make a significant impact on the equity, efficiency and sustainability of human settlements. The SDF capital investment framework must be informed by the following: • Section 6(1)(h)(i)(l) of Act no 36 of 1998 • Section 9(1)(a)(c)(f) of Act no 36 of 1998 • Section 13(c)(j) of Act no 108 of 1997 • Section 39(a)(c)& (2) of Act no 10 of 2004 • Section 24(3)(d)(e) of Act no 107 of 1998
(o)...determine the purpose, desired impact, and structure of the land use management scheme to apply in that municipal area	Develop guidelines for the LUS of the municipality (see Table 2)

Source: Own Construction (2018)

The complexity of spatial proposals can be discussed at length. For the purposes of this study, only certain aspects including i) growth management and ii) infrastructure requirements will be highlighted.

Growth management - In South Africa, there is a specific trend of locating large housing areas for the poor towards the periphery of the city – known to cause to urban sprawl. As sprawl continues, so will environmental degradation as natural landscapes become hindered by development. Recent attempts to combat urban sprawl, or sprawl in general (either as a means to achieve sustainability or as an attempt to integrate previously segregated communities into the urban fabric) has given rise to different techniques for managing growth. An urban growth boundary or urban edge is one of the planning tools used to limit the expansion of development footprint and controlling sprawl.

Another tool, or rather a strategy, adopted by many municipalities is a densification strategy, which promotes higher density development in targeted areas usually achieved through other regulatory tools such as zoning and development controls. The terms urban edge, urban development boundary, or densification strategy are often used interchangeably in spatial planning documents.

The following are some definitions from the literature:

- An urban edge is a demarcated line to manage, direct and control the outer limits of development around an urban area. The intention of an urban edge is to establish limits beyond which urban development should as a rule not occur and to promote urban and environmental efficiency, effectiveness and economies in the interest of all (Western Cape, 2005);
- An urban growth boundary is a mapped line that separates land on which development will be concentrated from land on which development will be discouraged or prohibited (Sitko, 2005);
- The urban edge is a virtual development boundary and inter-related policy that serves to control urban sprawl by mandating that the area inside the boundary be used for higher density urban development and the area outside be used for lower density, green open spaces and/or no development. The urban edge forms the boundary between urban development and the valuable natural and agricultural hinterland in order to contain the lateral growth of the urban areas (City of Tshwane, 2012).
- Density is a key concept in planning, architecture and urban design that is used to describe, predict and control the use of land. It is a measure of thresholds, urban efficiencies and the intensity of residential development, and is part of a suite of tools for city building (eThekweni Municipality, 2013:5);
- The increased use of space, both horizontally and vertically, within existing areas/properties and new developments, is accompanied by an increased number of units and/or population threshold (City of Cape Town, 2012:5)

In South Africa, one would barely ever find an urban edge, urban development boundary or densification strategy assigned to rural settlements. One of the reasons can be traced back to the era of apartheid spatial planning when the practice of spatial planning was limited to urban areas. Another reason could be related to the sure informationally of rural areas, expanding rapidly and uncontrollably without any legal regulations. The SPLUMA requires for SDFs to be, amongst others, be inclusive, promote sustainability, and achieve spatial justice. In this regard, SDFs should direct growth towards existing socio-economic opportunities through densification strategies to achieve inclusivity, limit growth beyond existing built-up areas through a urban development boundary or growth management strategy to promote environmental sustainability – as a result, spatial justice not only for people but also for the environment can be achieved.

Infrastructure requirements - In terms of services, most of South Africa's rural settlements still suffer from inadequate access to water and sanitation services. In other areas, unaffordable high levels of services are provided to communities, often resulting in wasteful usage as the resource is "free". Section 21(1)(h) of SPLUMA also requires for SDFs to "identify, quantify and provide location requirements of engineering infrastructure and services provided for existing and future development needs for the next five years". The spatial location (where) of developments can have a severe quantitative impact on water resources. The SDF should, therefore, direct development towards areas where existing infrastructure has the potential to increase its carrying capacity – ultimately reducing the UARL within a system. In terms of services delivery, the SDF must give effect to, and align with the municipality's WSDP. However, both plans should consider a leaf-frog approach towards water sensitive services (alternative solutions) in poorly/un-serviced informal settlements as suggested by Armitage *et al*, (2014). Such technologies can induce rainwater harvesting, stormwater harvesting, greywater reuse systems, and waterless toilets or constructed wetlands to treat effluent.

4.4.2 Water Sensitive Land Use Scheme

The legislative requirements for developing and implementing a municipal land use scheme (LUS) has radically changed since the commencement of the SPLUMA. Section 4 of SPLUMA specifies that a municipality must adopt and approve a single LUS for its entire municipal area within five years from the commencement of the Act.

Prior to SPLUMA, land use schemes (or zoning schemes) mostly covered only urban or developed town areas, excluding the broader and much larger rural areas characterised by informal settlements, former homelands, and areas of widespread poverty and deprivation from the benefits of land use management (Strauss & Liebenberg, 2014:343; Charlton, 2008:18; Parnell & Pieterse, 2010:153).

For this reason, the SPLUMA acknowledges the challenges associated with introducing land use management within these areas, some of which include limited data and absence of surveyed sites, lack of information on boundary verification of individual properties, and lack of ownership information on these locations (Nel, 2016:81). Furthermore, the right to allocate land for occupation is viewed as one of the core roles of traditional authorities (discussion between Author and official from Department of Rural Development and Land Reform: 2016). However, implicit in the allocation of land is the determination of land use. Unfortunately, very few traditional chiefs have the necessary skills, tools and exposure to give effect to principles of sustainable development adequately (Interview with Mr. W Fourie).

Furthermore, many traditional leaders see the imposition of land use management schemes and land use decisions by the municipality as mandated by the SPLUMA as intruding on their traditional authority (Nel, 2016:81). In acknowledging the above concerns, the SPLUMA provides for the “incremental introduction” as defined in Section 24(2)(c) of land use management in areas previously not subject to a land use scheme. Giving effect to a land use scheme is yet another concerning matter; however, it is beyond the scope of this discussion.

Unlike other plans, the land use scheme is a legal instrument that grants developmental right on each registered land parcel or an erf. Section 26 of the SPLUMA states that land may only be used for the purposes permitted by a land use scheme (South Africa: 2013). A land use scheme adopted in terms of the SPLUMA must consist of regulations setting out the procedures and conditions relating to the use and development of land in any zone, a zoning map, and a register of all amendments to such land use scheme. Every property in the municipality is subject to a set of development parameters, often called “scheme regulations” which can include development control and/or building controls that set out all procedures and conditions associated with the use of land on any property. Scheme regulations are therefore used to give effect to an SDF's initiatives or strategies. One of the key benefits of a LUS, within the context of this study, is that it can legally promote and protect amenities such as natural resources.

Table 4-9 summarises how a municipal LUS can give effect to WSS and align with water and environmental resource planning and management. Actual implementation thereof will be assessed throughout Chapter 5.

Table 4-9: Section 24(2) of Act 16 of 2013 - towards water sensitivity

A Municipal LUS must...	How to plan for water sensitivity
(a)“...include appropriate categories of land use zoning and regulations for the entire municipal area”.	Zonings are typically assigned to land, which then determine the legal use of land. Zonings can be used to give effect to cities / settlements that prove ecosystem services and water supply catchment (Wong & Brown 2009) by: • assigning scheme clauses to specific zonings that regulate the coverage of a site and/or permeability of a site; • establishing appropriate lot sizes, and other development controls such as the size of the swimming pool; • limiting or enhancing density; • requiring adequate drainage; • and prohibiting potentially polluting land uses in areas where surface water and groundwater resources must be protected. Building controls, linked to a zoning can also be used to legally enforce the use of alternative water sources such as greywater or require that, e.g. 30% of runoff must be stored in a storage facility and reused onsite. Zoning codes and scheme clauses must address site-specific ecological conditions. Zoning as assigned by a LUS must be informed by the following: • Section 6(1)(h) of Act no 36 of 1998

	• Section 9(1)(a) of Act no 36 of 1998 • Section 13(j) of Act no 108 of 1997 • Section 39(a)(c) & (2) of Act no 10 of 2004 • Section 24(3)(d)(e)(f) of Act no 107 of 1998 • Section 41(2)(a) of Act no. 57 of 2003
(b)"...take cognisance of any environmental management instrument adopted by the relevant environmental management authority , and must comply with environmental legislation"	To achieve cities / settlement that prove ecosystem services (Wong & Brown 2009) a LUS includes appropriate zonings for areas of ecological importance as identified by the relevant environmental management authority. These zonings or overlay management zones can: • prohibit development on or close to rivers, wetlands, impoundment, estuaries, areas with high groundwater recharge potential, protected areas, CBA, ESA and all FEPAs identified as current and future structuring elements that will affect the future spatial form; • a management overlay zone can also be used as a temporary management tool where certain environmental areas might need time to rehabilitate. • legally give effect to the land use management guidelines as prescribed by the environmental management authority. The LUS must take cognisance of the following: • Section 39(a)(c) & (2) of Act no 10 of 2004 • Section 24(3)(d)(e)(f) of Act no 107 of 1998 • Section 41(2)(a) of Act no 57 of 2003.
(c)"...include provisions that permit the incremental introduction of land use management and regulation in areas under traditional leadership, rural areas, informal settlements, slums and areas not previously subject to a Land Use Scheme"	The incremental introduction of land use management in previously excluded areas can give effect to settlements that prove ecosystem services, as the spatial delineation of areas representing ecological significance can be used by the Chief to direct development away from such areas. Emphasising the importance of such resources should not be taken likely. The LUS can provide for: • a management overlay zone for areas identified as having high groundwater recharge potential; • areas to be prioritised for rehabilitation; • areas to be protected from future growth pressures; and • areas where land use has caused a detrimental impact on ecosystems.
24(e)"...include land use and development incentives to promote the effective implementation of the Spatial Development Framework and other development policies"	A LUS and its development controls or building controls have the ability to incentivise developers on a financial or non-financial manner. Development incentives can give effect to cities / settlements as water sensitive communities and water supply catchments (Wong & Brown 2009) by: • providing financial incentive when buildings are fitted or retrofitted with water sensitive technologies such as greywater reuse systems, water efficient faucets and toilets, rainwater or stormwater harvesting technologies; • non-financial incentives including, for example, increasing the allowable floor space ratio, or increasing the impervious area of a residential allotment, provided the development includes sustainability initiatives such as rainwater harvesting, living green walls, water re-use, and water efficient appliances. The LUS must take cognisance of the following: • Section 39(a)(c) & (2) of Act no. 10 of 2004 • Section 24(3)(d)(e)(f) of Act no. 107 of 1998 • Section 41(2)(a) of Act no. 57 of 2003.
"23(3)(a)(b)(c) A land use scheme may include the provision relating to specific requirements regarding any special zones identified to address the development	Special zones can give effect to cities / settlements providing ecosystems and water supply catchments (Wong & Brown 2009) by: • identifying special zones to be used for the construction of wetlands and attenuation ponds, also specifying areas which need river restoration, etc.; • including special zones provision for blue-green corridor developments.

priorities of the municipality” and “the variation of conditions of a land use scheme other than a variation which may materially alter or affect conditions relating to the use, size and scale of building and the intensity or density of land use”.	• assigning special zones to areas where land use has an irregular high-water quality impact or water quantity impact and assigning specific building regulations and development controls to such zones. Regarding conditions pertaining to the use, size and scale of buildings and the intensity of density of land use: • Scheme clauses should permit higher density infill development within the existing built-up footprint, reducing the need for long extended infrastructure networks which are energy and resource intensive;

Source: Own Construction (2018)

The complexity of scheme clauses can be discussed at length. For the purposes of this study, only certain aspects including management overlay zones, development controls, and building controls will be highlighted.

Management Overlay Zones – Land use schemes provide basic controls and regulations in respect of the nature and form of development possible on any parcel of land or area. However, in certain circumstances, there is a need to augment these controls with additional considerations or more detailed plans. Section 24(3) of SPLUMA grant municipalities, through their LUS the opportunity to include provisions relating to specific requirements regarding any special zones identified to address the development priorities of the municipality. In this instance, a management overlay or management overlay zone may be used to further inform and regulate development, i.e. overlays are used in schemes to facilitate the management of specific uses across and in addition to several underlining zonings. A management overlay applies to a defined area of land with a distinct set of intentions or policy guidelines that influence and facilitate its development in a unique or specific manner, and may not have an exact cadastral boundary. Management overlay zones can be shown spatially and can, therefore, be used to:

- i) demarcate an environmental or conservation management plan for and areas, and
- ii) manage detailed area-specific development plans.
- iii) provide general and/or specific guidelines for particular types of development;

Regarding the demarcation of an environmental or conservation management plan, the land use scheme can provide for an overlay zone to give effect to its bioregional plan (if any) and/or provincial Spatial Biodiversity Plan. As noted in Section 4.2.3.2 these plans should delineate the spatial location of CBAs and ESAs and provide land use management guidelines for each. As the bioregional and provincial Spatial Biodiversity Plan has limited legal force, the municipal LUS should provide legal protection for CBAs and ESAs to regulate land use on a more detailed spatial scale.

Table 4-10 provides an example of the specific land use guidelines assigned to CBAs and ESAs in within the Waterberg district.

Table 4-10: Land use guidelines for CBAs and ESAs

No	Land Use Zone	Associated Land Use Activities	CBA1	CBA2	ESA1	ESA2
1	Environmental Conservation	Conservation management, low-intensity eco-tourism activities and sustainable consumptive activities.	Y	Y	Y	Y
2	CBA Map Overlay Zone / Bioregional Planning Overlay Zone	These are areas that are designated as biodiversity priority areas, namely CBAs and ESAs;	Y	Y	Y	Y
3	Tourism and Accommodation	Low Impact Tourism / Recreational and Accommodation.	R	R	Y	Y
		High Impact Tourism / Recreational and Accommodation (e.g. golf estates).	N	N	N	R
4	Rural Residential	Low-density rural housing or eco-estates.	R	R	R	R
		Traditional Areas (existing) and Rural Communal Settlement (New).	N	N	R	R
5	Agriculture	Extensive Game Farming	Y	Y	Y	Y
		Extensive Livestock Production	Y	Y	Y	Y
		Game Breeding / Intensive Game Farming	N	N	N	N
		Arable Land - Dryland and Irrigated Crop Cultivation	N	N	R	Y
		Plantation Forestry: Timber Production.	N	N	N	Y
		Agricultural Infrastructure - Intensive Animal Farming (e.g. feedlot, dairy, piggery, chicken battery).	N	N	N	N
6	Municipal Commonage	Local Agri-economic development.	N	R	R	Y
7	Open-Space	Public or Private Open-Space, including recreational areas, parks etc.	Y	Y	Y	Y
8	Residential	Low, low-medium, medium-high, and high density urban residential development. (= NW = Urban & Business Development)	N	N	N	N
9	Urban Influence	An amalgamation of land use zones, including Institutional, Urban Influence, General Mixed Use, Low Impact Mixed Use, Suburban Mixed Use and General Business. (= NW = Urban & Business Development)	N	N	N	N
10	Low or High Impact and General Industry	Low Impact, General Industry and High Impact Industry (Urban & Business Development).	N	N	N	N
12	Transport Services	Transportation service land uses e.g. airports, railway stations, Petro-ports and truck stops, bus and taxi rank and other transport depots. = NW = Linear Engineering Structures)	R	R	R	R
13	Roads and Railways	Existing and planned linear infrastructure such as hardened roads and railways, including activities and buildings associated with road construction and maintenance, e.g. toll booths, construction camps and road depot sites. (Linear Engineering Structures)	R	R	R	R
14	Utilities	Linear engineering structures, such as pipelines, canals and power lines. (Linear Engineering Structures)	R	R	R	R
		Small-scale Infrastructural installations, including wastewater treatment, works and energy sub-stations	N	R	R	R
		Large-scale Infrastructure installations, including bulk water transfer schemes, impoundments (Water Projects & Transfers), and energy-generation facilities (powers stations).	N	N	N	N
		Renewable Energy (PV farms and solar arrays)	N	N	N	N
		Renewable Energy (wind farms)	N	R	R	R

15	Quarrying and Mining	Prospecting and Underground Mining	N	R	R	R
		Quarrying and opencast mining (includes surface mining, dumping & dredging).	N	N	N	N
		Hydraulic Fracturing	N	N	R	R
Y	YES, permitted and actively encouraged activity					
N	NO, not permitted, actively discouraged activity					
R	RESTRICTED to compulsory, site-specific conditions & controls when unavoidable, not usually permitted					

Source: Waterberg District Municipality (2016)

In achieving water sensitivity, the LUS should provide for additional measures through a Management Overlay Zone to improve water quality and quantity, specifically in areas identified as FEPA. This relates to the second matter of area-specific management. According to Driver *et al.* (2011:2) the NFEPA spatial data must be used to inform land use planning and decision-making processes which affects freshwater ecosystems. Chapter 6 of the Implementation Manual for Freshwater Ecosystem Priority Areas guides planning and land use in and around FEPA ecosystems (Driver *et al.*, 2011). According to Driver *et al.* (2011:69-90) “The land-use practices and activities highlighted in the guidelines are known to influence the drivers of ecosystem condition (hydrology, geomorphology, water quality), which in turn determine habitat attributes (e.g. habitat availability and condition), which in turn determine biological responses”. Table 4-11 summarises the management guidelines for wetlands, rivers, sub-quaternary catchments associated with rivers and upstream management areas and FEPA for land use practices or activities. These parameters can be and should be included in as part of a Management Overlay Zone in the municipal LUS.

Table 4-11: Land use management guidelines for NFEPA

Buffer	Description	FEPA Wetland	FEPA Rivers	Quantity	Quality
100 m Buffer	Afforestation with invasive alien tree species should not be allowed. New Plantations should be located at least 100 m away from wetland buffers and riverine area.	x	x	x	
	Flood control berms should not be placed in or close to, less than 100 m from wetland and river FEPAs	x	x	x	
	Polluted agricultural runoff , such as irrigation return flows from fertilized fields, should be conveyed overland at least 100m before flowing into a wetland or river FEPA.	x	x	x	
	Septic tanks and soakaways should be located at least 100 m from a wetland or river FEPA buffers.	x	x	x	
250 m Buffer	If a new borehole is proposed closer than 250 m to a wetland or river FEPA buffer, a hydrogeological investigation should establish the dependence of the wetland and river on groundwater sources, or whether the wetland may be an important groundwater discharge point. If groundwater dependence is established, or if the wetland or river is an important groundwater discharge point, the borehole should be located at least 250 m away from the edge of the wetland or river FEPA buffer.	x	x	x	

	Well-points and boreholes should not be located in or close to (less than 250 m) from a wetland or river FEPA or its buffer, even where there is sufficient evidence to show that the wetland is not sustained by groundwater.	x	x	x	
500 m Buffer	Areas irrigated through discharge of treated wastewater should be located at least 500 m outside the riverine buffer.		x	x	
	Herbicides and pesticides should generally not be used within 500 m of wetland or river FEPAs, except for managed invasive alien plant removal.	x	x		x
	New or upgraded wastewater treatment works should preferably not be located within 500 m of a wetland or river FEPA or its buffer.	x	x		x
1000 m Buffer	Mining or prospecting in any form should not be permitted within 1 km of a wetland buffer or riverine buffer.	x	x	x	x
	Weirs should preferably not be built within 1km downstream of wetland FEPA unless for the purposes of rehabilitation.	x		x	
2000 m Buffer	Weirs should preferably not be built within 2 km upstream of a wetland FEPA unless for the purposes of rehabilitation.	x		x	

Source: **Driver et al. (2011:69-90)**

Lastly, the Management Overlay Zone provide can provide for general and/or specific guidelines for particular types of development. More commonly referred to as Development Controls or Building controls. They are, however, to confined to Management Overlay Zone.

Development controls - A municipality manages development through a series of development controls or parameters, relating to each zoning that detail the requirements in respect of buildings, built form and sub-divisional matters. Typical development parameters to include in a scheme include:

- Density as the number of dwelling units per erf/lot or per hectare
- Height restrictions expressed as the number of storeys or in metres above ground level or above mean sea level
- Floor Area Ratio (FAR) or the ratio of the total floor area of the building to the total area of the subdivision on which the building is or is to be erected
- Coverage – the percentage of the plot that may be covered by a building or roofs
- Parking and vehicle loading requirements
- Building lines/space around buildings

RULES REGARDING THE EXTENT OF DEVELOPMENT				
Maximum Density:	Maximum Coverage:	Maximum FAR:	Maximum Height:	Other:
Maximum of 40 dwelling units per hectare.	60%	1.00	3 storeys	As may be approved by the municipality from time to time.
RULES REGARDING BUILDING LINES			RULES REGARDING PARKING AND LOADING	
Street boundary:	5 metres for municipal streets. 2 metres along internal streets.		1 covered and 1 uncovered spaces per dwelling unit. For non-residential uses, refer to Chapter 8.	
Rear boundary:	2 metres for municipal streets. 1 metre along internal boundary.			
Side boundary:	2 metres for municipal streets. 1 metre along internal boundary.			

Figure 4-10: Example of Development Controls

Source: RDLR (2017)

Based on the literature review presented in Section 4.3.1, each of these development controls can be customised to cater for water sensitivity development, for example:

- Density can be increased to the expansion of the built footprint beyond its existing built-up areas – until the time comes when no more infill development can be accommodated. This will not only protect the broader environment, but it will also reduce the UARL throughout a water distribution system.
- Height restrictions or allowance can be increased if the developer implements rainwater harvesting of green roofs to reduce the volume of runoff – protecting stormwater from surface contamination and also using the resource as a substitute for non-potable uses.
- Floor Area Ratio (FAR) can also be increased if the development implements underground water storage facilities to harvest stormwater from parking bay etc. FAR can also be limited to make provision for SuDS to treat runoff within a specific location.
- Coverage/permeability, similar to FAR, coverage can be restricted or increase as according to the needs of the specific location. The development controls should regulate the use soakaways and permeable paving so that runoff to seep back into the ground rather than being carried into the drainage systems.
- Parking and vehicle loading requirements can include the use of local SuDS controls to reduce the pollutant load from impermeable surface or, permeable paving can be set as a requirement for all parking or vehicle loading areas.
- Building lines/space around buildings can be used to utilise specific areas to be used for SuDS.

Building controls - Buildings are regulated in terms of the National Building Regulations and Building Standards Act. Building controls are concerned with the manner in which buildings are erected. No building can be approved if the development rights (in terms of a land use scheme) on that property to be built does not meet the specific requirements of such building control imposed by

the municipal land use scheme. The building is approved through a building plan submitted to the municipality. The municipal LUS can make recommendations for buildings in a specific area, either through a Management Overlay Zone or through scheme clauses. This interaction between the LUS (which in turn is influenced by the SDF) allows for a practical way of implementing certain policy decisions. An example of such can be found in the City of Tshwane Land Use Scheme, who introduced changes to their building regulations in 2013 specifically aimed at the conservation of energy. Building plans of new buildings have to conform to a certain energy efficiency value (mostly obtained through fitting a specific type of window glass) before the plan is approved. This could in future also apply to water efficiency in buildings as proposed by the City of Cape Town's Green Buildings Guidelines (City of Cape Town, 2012:19-22):

- ensure that only water-efficient devices such as low-flow taps, low-flow showerheads, low flow toilets or dual flush toilets are used;
- encourage rainwater harvesting and the re-use of grey water where appropriate;
- encourage the use of indigenous planting and efficient irrigation methods, such as drip irrigation;
- consider restricting the size of swimming pools and mandate the use of pool covers to reduce evaporation; and
- introduce waterless sanitation and alternative grey-water systems that clean black and grey water, while providing useful by-products such as fertiliser and biogas.

In conclusion to this section, the municipal SDF and LUS, as required by SPLUMA, are the ideal tools to give effect to the concept of water sensitivity, and for creating cities/settlements that provide ecosystem services; cities/settlements acting as water catchments; and, cities/settlements as water sensitive communities.

4.5 Conclusion

Throughout this study, it was highlighted that the transformation and occupation of land has both a qualitative and quantitative impact on natural resources. Land-cover change is widely recognised as the major driver of habitat and biodiversity loss (see discussion in Section 2.3.2.2). The existing state of freshwater resources in South Africa suggest that unregulated land use activities can be held liable to a larger extent. As the country's population continues to grow, the impact on water resources will become even more severe if the theory and practice of spatial planning and land use management does not adapt to socio-economic and physical changes.

The literature review, contained in this Chapter, revealed that South Africa has a plethora of strategic planning instruments aimed at protecting and sustainably using natural resources facilitated through cross-sectoral alignment of the hierarchy of plans. However, these plans often exist in isolation, while others do not exist at all.

Land use information is one area where alignment can be strengthened, as land use data is a key informant for developing CMSs (water sector) and EMFs (environmental sector). This implies that when and where CMSs and EMFs are being prepared, information will align to that of the municipal SDF and LUS. There is a true need for better alignment of water, environmental and land related resource planning and management.

Nevertheless, South Africa is on the road to recovery as the country recently adopted the concept and aim of achieving WWS as a response to the lurking water threats. While there is currently an abundance of information on the SuDS and WSUD provided by Armitage *et al.* (2013) and Armitage *et al.* (2014). Few references in local and international literature can be found that directly deal with spatial planning and land use management as a tool to address problems of water scarcity or water quality.

This study identified the municipal SDF and municipal LUS as two planning tools which can give effect to water sensitivity within the urban and regional planning domain. Table 4-8 and Table 4-9 identified several opportunities through which a SPLUMA compliant SDF and LUS can give effect to achieving WSS. The tables also provide information as to how they can promote better alignment with water and environment resources planning strategies.

The following chapter provides information as to how innovative and evidence based spatial planning and land use management practices can help secure future water resources.

CHAPTER 5 WATER SENSITIVE SPATIAL PLANNING APPROACH IN TWO LOCAL MUNICIPALITIES

5.1 Introduction

The previous chapters placed the global water resource challenge into perspective and highlighted key national concerns regarding future water resource availability in South Africa. Thus far, the study identified the international concept of WSC and, WSS adopted locally as a means to secure future water resources for South Africa. While an abundance of literature and case studies on the technical design and small-scale implementation and operation of SuDS and WSUD technologies exist, information on the role and practical implementations of spatial planning and land use management within the concept of WSS and more specifically, within the limitations of South Africa remains unexplored. This chapter builds on the concept of WSS by evaluating water sensitivity within two local municipalities.

Section 5.2 provides for a description of the methodology employed throughout the empirical investigation, consisting of three phases. The research investigation and findings of Phase 1 is provided in Section 5.3; the research investigation and findings of Phase 2, is provided in Section 5.4; and, the research investigation and findings of Phase 3, is provided in Section 5.5. A conclusion is drawn in Section 5.7.

This chapter is structured as follow (see Figure 5-1):

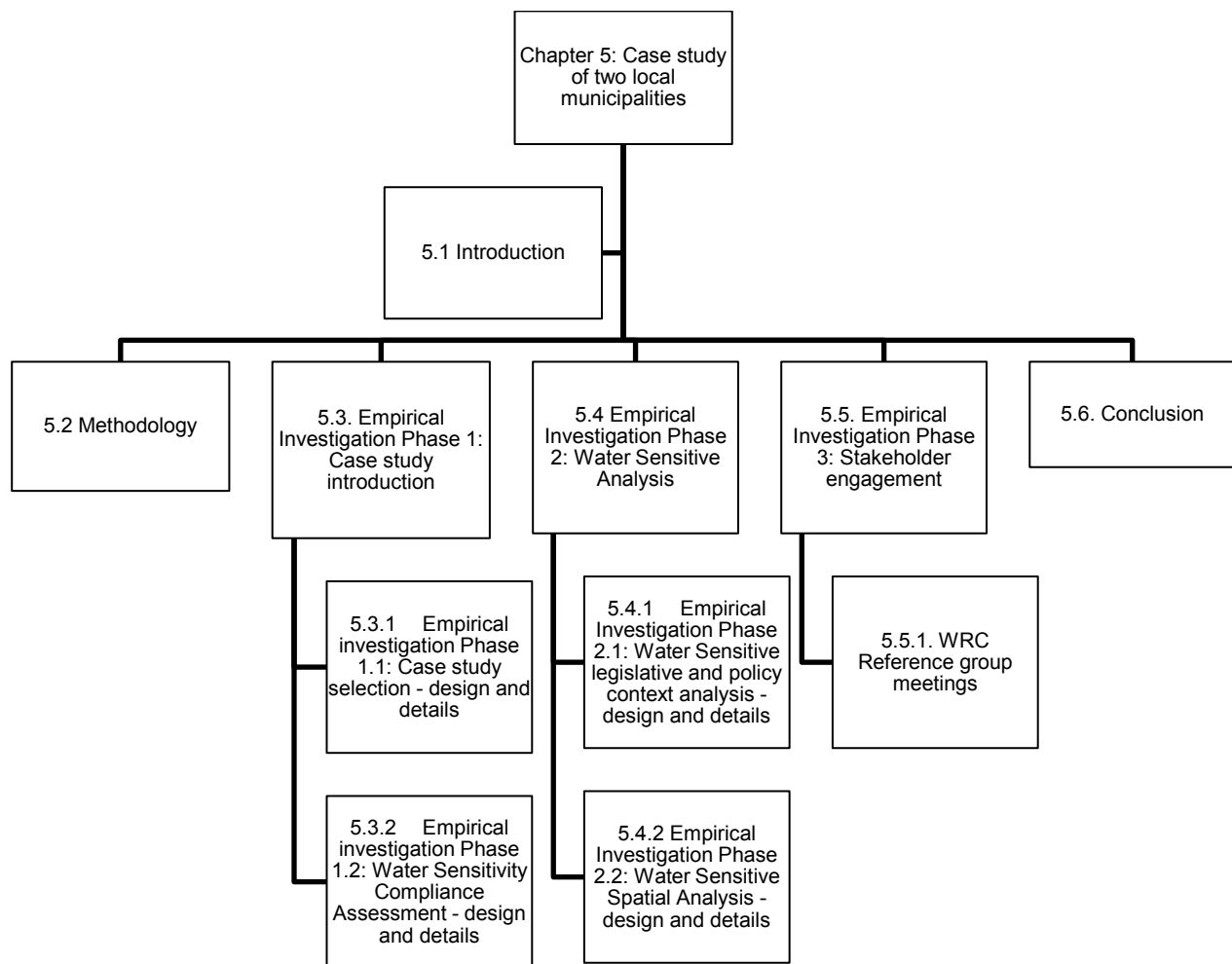


Figure 5-1: Conceptual structure Chapter 5

Source: Own Construction (2018)

5.2 Methodology

The primary research aim of the study is to develop innovative and evidence based tools through which spatial planning and land use management practices can secure future water resources. The study, therefore, identified two planning tools, the municipal SDF and municipal LUS and, two case study areas, Lephalale and Mogalakwena Local Municipality to be evaluated in terms of their existing planning practices and future opportunities on how spatial planning and land use management practices can give effect to water sensitivity. The empirical investigation adopted three phases, consisting of various research methods as illustrated in Figure 5-2.

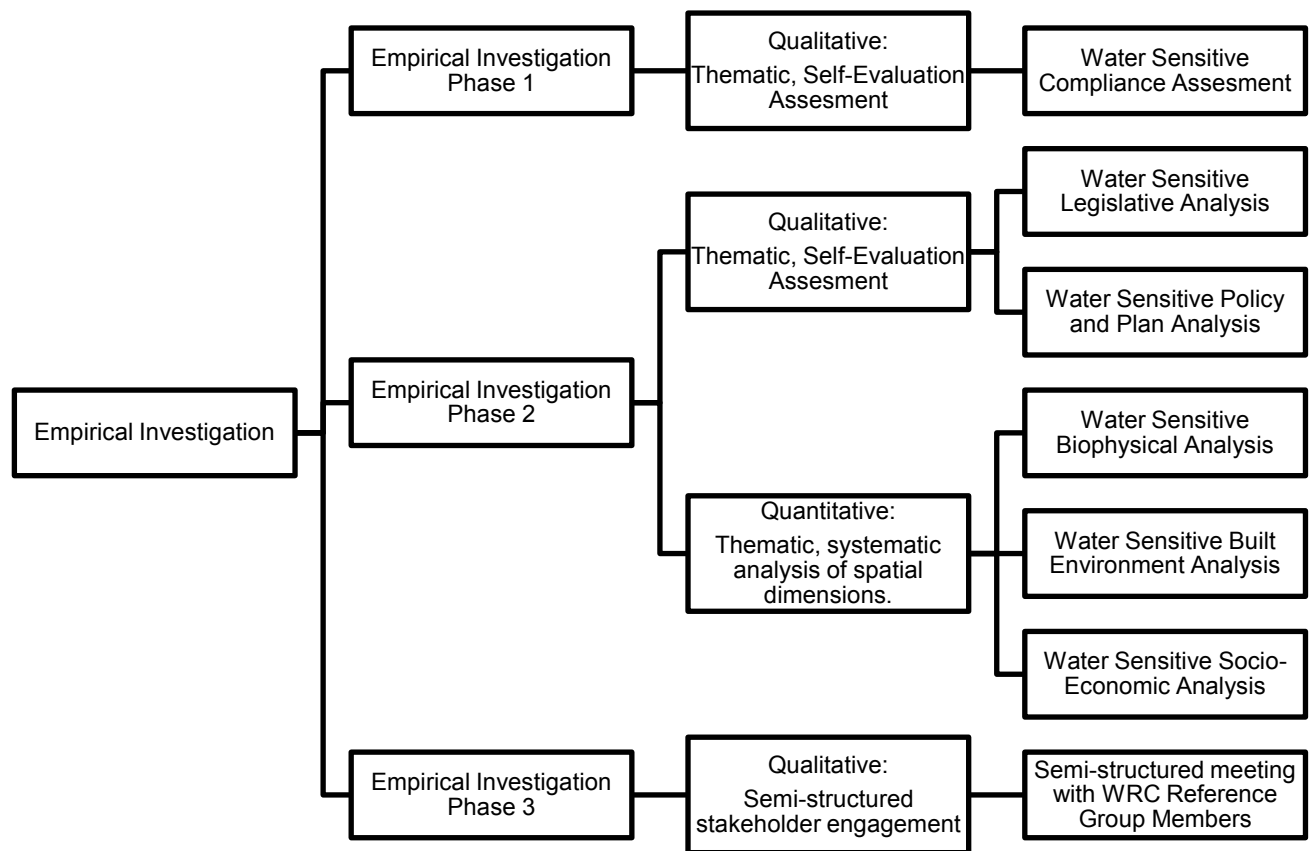


Figure 5-2: Empirical Investigation - research structure

Source: Own Construction (2018)

Each research phase is discussed in greater detail in the sections to follow.

5.3 Empirical Investigation Phase 1: Case study introduction

Section 5.3.1 provides reasons for the case study selection, which is further reflected on in Section 5.3.1.1 and Section 5.3.1.2. Section 5.3.2 elaborates on the detail and design of the Water Sensitive Compliance Assessment, while Section 5.3.2.1, Section 5.3.2.2 reveals the results, and Section 5.3.2.3 provides a brief discussion on the key findings of the Water Sensitive Compliance Assessment.

5.3.1 Empirical investigation Phase 1.1: Case study selection - design and details

There were two main reasons for selecting Lephalale and Mogalakwena Local Municipality as case studies:

- Both case study areas represent characteristics of a typical Category B municipality which according to Section 4.2.2.2 have the highest volume of NRW, making them extremely water wasteful in terms of service delivery. Both municipalities are scorned by apartheid spatial planning and are still today characterised by low density sprawling settlements, with growing rural settlements; high levels of household poverty and joblessness; high level of backlog in services; located in water-stressed regions - exuberated by water-intensive land uses and deteriorating ecological infrastructure due to unplanned and uncontrolled expansion of rural settlements. In essence, both municipalities capture the philosophy of water sensitivity in South Africa, as defined by Armitage *et al.* (2014) (see Section 4.3.2).
- The researcher also has good working relations in both municipalities as the researcher was part of the project team appointed to conduct a wall-to-wall land audit for both municipalities. This gave the researcher access to reliable land use spatial data. Additional information on property zoning, ownership, and date of the establishment were also provided. This is unique, as most municipalities still only have spatial data representing land use in urban areas - excluding all other informal, rural or village land use data. It should be noted that zoning information is limited to urban areas as rural settlement have, to date, not been subject to land use schemes. Thus, some of the spatial assessments could only be conducted for urban areas as zoning information was required for certain reasons (to be explained in the methodology).

Section 5.3.1.1 and Section 5.3.1.2 reflects on Lephalale and Mogalakwena Local Municipality and provides a brief overview of both municipalities existing land use spatial data.

5.3.1.1 Lephalale Local Municipality: Study areas overview

Lephalale Local Municipality (LIM362) covers a geographic area of 13 784 km² and is situated within the Limpopo Province, forming part of the administrative boundary of the Waterberg District Municipality. In terms of water resources, the municipality is found within the Limpopo Water Management Area, Primary Catchment A with A4 and A5 as secondary catchments. The municipality has three perennial rivers, including the Lephalala river, the Limpopo river which runs along the Botswana border, and the Mokolo river which splits the municipality in two, east and west.

On a macro level, the land audit data reveals that approximately 39.13% of Lephalale's landscape is untouched and in a natural state. Only 0.56% of the municipality's surface area is covered by water bodies which include all rivers and wetlands, permanent or seasonal. Agricultural practices cover approximately 4.48% of the municipality's surface areas.

The bulk of which is used for cultivated commercial fields followed cultivated commercial pivots, subsistence farming, orchards and plantations. Mining practices take up 0.25% of the municipality's surface area of which the majority, 25 km² is currently in a bare vegetated state and 8 km² remains semi-bare.

In terms of urban and rural land use, the location and type of land use are mainly determined by the municipality's population or household distribution. In 2011, Lephalale Local Municipality had an estimated population figure of 115 767 which roughly equates to 29 880 household's (Stats SA, 2011). At the time, 56% of Lephalale's households were located in the municipality's 35 rural settlements, while 44% of households were located in urban settlements. More specifically, in Ellisras, Onverwacht and Marapong.

According to the land audit data, 42.43% of all urban land uses are currently vacant; 20.78% is used for residential purposes followed by land used for roads and public services infrastructure at 15.04%. Educational (4.83%), Community (4.57%), Business (4.01%), Government (2.64%) and Industrial (1.09%) land use all amount to less than 5% each. The land audit also reveals that 4.24% of land uses are assigned to natural open spaces, while land used for recreational purposes amount to 0.38% (see Figure 5-3).

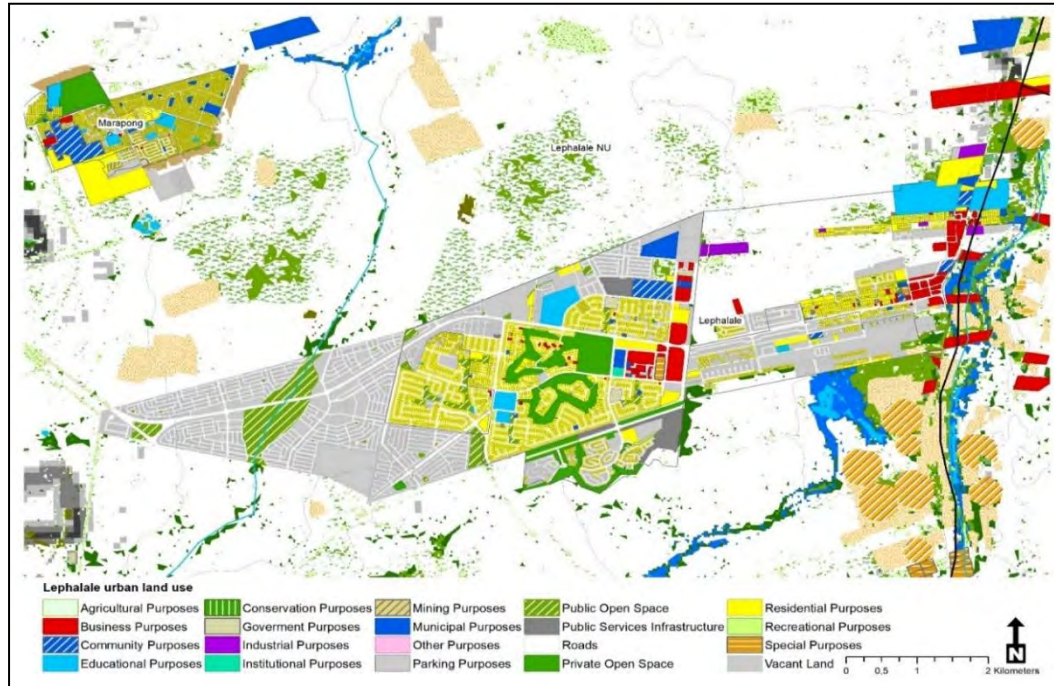


Figure 5-3: Lephalale's urban land use

Source: Own construction (2018)

As for Lephalale rural settlements, the land audit data reveals that 49.71% of informal land uses' is used for residential purposes, 23.75% of which is currently vacant. Open spaces account for 8.81%, agricultural purposes for 6.66%, and land used for recreational purposes accounts for 1.22% of all village land uses. These land uses are often confused due to their informal nature (see Figure 5-4).

The land audit data also provides spatial information on zonings, limited to urban areas, property ownership and growth. While an in-depth review of each is unnecessary, it should be noted that the growth data indicates that Lephalale's rural settlements grew much faster than its urban areas. A growth trend that was not predicted at all, hence the many vacant urban stands in Ellisras.

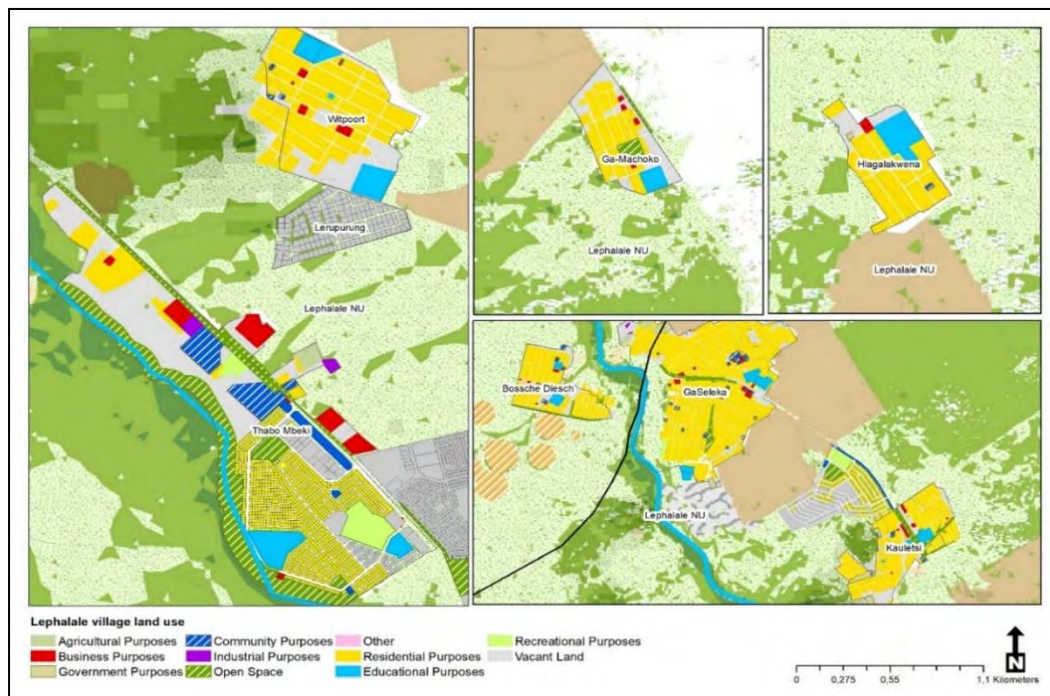


Figure 5-4: Lephalale's village land use

Source: Own construction (2018)

5.3.1.2 Mogalakwena Local Municipality: Study areas overview

Mogalakwena local municipality (LIM367) covers a geographic area of 6 166 km² and is also situated within the Limpopo Province, forming part of the administrative boundary of the Waterberg District Municipality. The municipality is found within the Limpopo Water Management Area, Primary Catchment A with A5 and A6 as secondary catchments. It has two perennial rivers including the Lephalala river and the Mogalakwena flowing south to north nearly bisecting the municipal area which is defined by the Waterberg in the west and the Strydpoort mountains in the south-east.

On a macro level, the land audit data reveals that approximately 86,44% of the municipality's landscape is untouched and in a natural state, while 0.24% of its surface areas is covered by water bodies which include all rivers and wetlands, permanent or seasonal. In Mogalakwena, wetlands take up 9.64 km², permanent water bodies occupy 4.10 km², while seasonal water bodies cover 9 650 km² of the municipality's surface area. The municipality's primary river network stretches over approximately 150 km and the secondary rivers approximately 490 km.

The land audit data reveals that Agricultural practices take up 8.92% of the municipal surface areas, the bulk of which is used for cultivated subsistence farming followed by cultivated commercial farming practices including fields, pivots and orchards and plantations. Mining practices take up 0.35%, the majority 21 440 km² thereof is currently in a bare vegetated state and 9 550 km² is semi-bare.

In 2011, Mogalakwena Local Municipality had an estimated population figure of 307 682 which roughly equates to 79 395 household's (Stats SA, 2011). The 2011 census results revealed that only 29% of Mogalakwena's households were located in urban areas, mostly in Mokopane and Mahwelereng. While 71% of households were scattered throughout the municipality's 121 rural settlement areas. Figure 5-5 depicts the spatial distribution of Mogalakwena's urban land uses, and Figure 5-6 the rural land use distribution in several informal village areas.

The land audit revealed that 21.90% of Mogalakwena's formally registered and surveyed urban erven is currently vacant, 41.61% is currently used for residential purposes followed by 20.20% currently used for roads and public services infrastructure. Business land use amount to 2.5% and are mostly located within Mokopane's CBD. Industrial land use is predominantly located towards Mokopane's northern region covers a spatial area of 1.89 km². Only 0.75% of all land use is used for government or municipal purposes. Public open spaces account for 0.42% of Mogalakwena's urban land use.

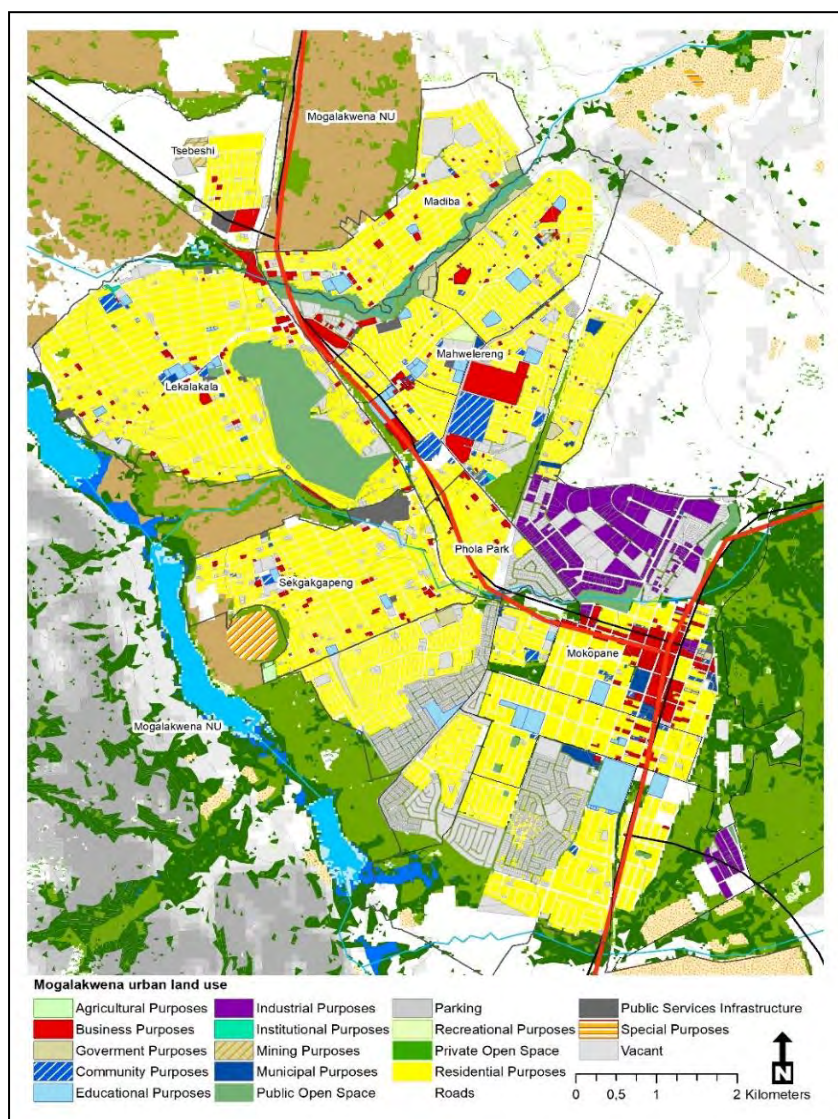


Figure 5-5: Mogalakwena's urban land use

Source: Own construction (2018)

As for rural land use, the land audit data reveals that 44.64% is currently being used for agricultural purposes, 43.52% for residential purposes of which 23.75% is currently vacant. Several businesses accounting for 1.41% of all rural land use can be found mostly located in Tshamahansi, Bakenberg and Mapela. Informal Industrial land uses represent 0.09% of all village land uses. Although the coverage is not significant, these land uses have a high water resources impact which has gone unaccounted for many years now.

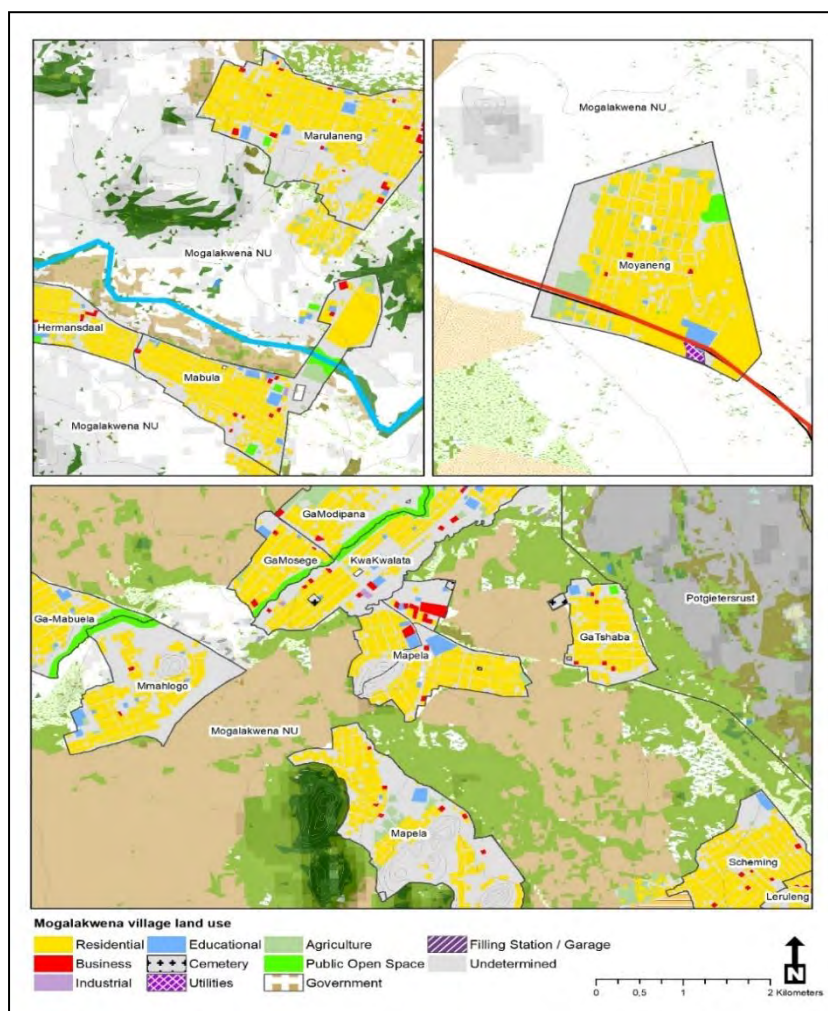


Figure 5-6: Mogalakwena's village land use

Source: Own construction (2018)

The spatial growth data indicates that between 2010 and 2018, Mogalakwena's formal areas expanded with over 1 186 Ha and informal areas with over 2 216 Ha. Overall Mogalakwena's urban areas expanded by 18.24% and informal areas by 7.41%. According to the spatial data, over the last 8 years, development has predominantly taken place on the settlement periphery. The spatial information suggests that a low density, sprawling development trend has been dominant over the past years. This development pattern holds water resource quality and quality implications.

In conclusion to the case study overview, the land use spatial data reported on in this section was used to conduct Phase 2.2 of the empirical investigation. Section 5.3.2 to follow, investigates who well each of the selected case study municipalities existing spatial planning and land use management tools comply with SPLUMA requirements and gives effect to the concept of water sensitivity.

5.3.2 Empirical investigation Phase 1.2: Water Sensitivity Compliance Assessment - design and details

Informed by the literature review of Chapter 4, specifically Section 4.3 and Section 4.4, this phase of the empirical investigation applied a self-evaluation assessment to both Lephalale and Mogalakwena's existing SDFs and LUSs to determine "how well" these planning tools comply with SPLUMA requirements and "how well" do they give effect to concept of water sensitivity. Self-evaluation, which is formative (Black & William, 1998:7-8) in this research, comprised of two key elements (Boud & Falchikov, 1989:529). Firstly, the identification of criteria (ranking scale) of the evaluation, and secondly the motivation of the ranking allocated.

As for the criteria, the assessment framework consists of a thematic investigation based on the SPLUMA requirements. The selected SDFs were assessed according to the following themes:

Theme 1: SPLUMA principles: Spatial Justice, Spatial Sustainability, Spatial Efficiency, Spatial Resilience and Good Administration;

Theme 2: Written and spatial representation of a five-year spatial development plan;

Theme 3: Spatial Vision;

Theme 4: Structuring and re-structuring elements;

Theme 5: Estimating Growth;

Theme 6: Engineering services, levels of service and water; and,

Theme 7: Environmental Assessment.

The selected LUSs were assessed according to the following themes

Theme 1: Preparation of Land use scheme

Theme 2: Alignment of planning tools

Theme 3: Zonings, scheme clauses and development controls

Considering the concept of water sensitivity, each theme was informed by context specific questions. The review proved that there is no truly right or wrong answer in determining compliance to SPLUMA and the concept of water sensitivity. Thus, the following colour coded ranking scale was used throughout the assessment (see Table 5-1).

Table 5-1: Assessment legend - review of planning documents

Fully addressed	The planning document examines and addresses the specific variable adequately.
Partially addressed	The planning document does examine and address the specific issue in question, but not in as much detail as would be desired.
Not addressed	The issue is not examined or addressed in the planning document whatsoever.

Source: Own Construction (2018)

Table 5-2 lists the spatial planning and land use documents that were assessed according to the sample framework. Note that the Lephalale's SDF and LUS were adopted in terms of SPLUMA, whereas Mogalakwena's SDF and LUS were adopted in terms of the Municipal Systems Act where the legal requirement for preparing SDFs and LUSs were extremely limited. This provides the investigation with the opportunity to determine if SPLUMA compliant SDFs and LUSs are more conscious towards water sensitivity, than those plans development prior to SPLUMA.

Table 5-2: Case study spatial planning and land use management documents

Document	Prepared and adopted in terms of:	Date of acceptance
Lephalale Local Municipality Spatial Development Framework (SDF)	SPLUMA of 2013	2017
Lephalale Land Use Scheme (LUS)	SPLUMA of 2013	2017
Mogalakwena Spatial Development Framework	Municipal Systems Act of 2000	2009
Mogalakwena Draft Land Use Scheme	To be adopted in terms of SPLUMA of 2013	2012

Source: Own Construction (2018)

Section 5.3.2.1 and Section 5.3.2.2 reveals the results of the thematic self-evaluation assessment conducted for both municipalities SDFs and LUSs.

5.3.2.1 Water Sensitive Compliance Assessment: SDF

Table 5-7 provides for the Water Sensitive Compliance Assessment conducted for Lephalale and Mogalakwena Local Municipalities SDF.

Table 5-3: Water Sensitive Compliance Assessment: SDF

Theme 1: SPLUMA principles: Spatial Justice, Spatial Sustainability, Spatial Efficiency, Spatial Resilience and Good Administration				
Water Sensitive Assessment Criteria		Lephalale SDF 2017	Mogalakwena SDF 2009	
1.1	To what extent does the SDF redress the past spatial imbalances such as confining particular groups to limited space, and the unfair allocation of public and natural resource?	One of the key thrusts of the Lephalale SDF is the integration of Marapong and Onverwacht. Marapong is a previously disadvantaged community located approximately 18 kilometres from Onverwacht (a major node with plenty of economic opportunities and high order community facilities). The SDF provides for a specific growth direction that will allow these communities, over time, to integrate with each other.	Land development must take place in an integrated manner, both spatially and institutionally. Historical distorted development patterns must be corrected by means of physical and social integration and the redirection of investment to areas with the highest value and accessibility.	
1.2	To what extent does the SDF give effect to sustainable development patterns by promoting land development in locations that are sustainable and limits urban sprawl (compact, integrated human settlements)?	The SDF calls for a more compact City. This should be achieved by implementing two growth management tools. The first is a conservative urban edge (or urban development boundary) that seeks to optimise existing infrastructure and limit urban sprawl. The second tool is financial disincentive. Vacant properties within the city boundaries should be taxed more to promote quicker development and prevent speculation. This should also lead to the municipality achieving return on infrastructure investment through property rates and taxes as well payments for services such as water, sanitation and electricity.	Uncoordinated urban development must be discouraged, and more compact and efficient development patterns must be promoted.	
1.3	To what extent does the SDF give special consideration to the protection of prime and unique agricultural land?	Lephalale Municipality does not exhibit much agricultural potential with dry and hot conditions prevailing. Game farming does occur in certain areas. In the rural focus area, many families depend on subsistence agriculture as main economic activity. These areas of existing agriculture have been identified in the SDF with "settlement edges" demarcated to prevent villages sprawling onto agricultural land. One of the key proposals for the Rural Focus area is also the establishment of Framer Production Units in 3 of the key nodes in support of Governments' Agri-Park policy.	Agricultural activities in Mogalakwena is divided into two major zones, crop farming zone (high potential intensive agricultural activities) and ranching zone (low-intensity cattle and game ranching activities). The SDF also states that high potential agricultural land should be protected	
1.3	To what extent does the SDF uphold consistency of land use measures in accordance with environmental management instruments?	Yes, the SDF incorporates the District Environmental Management Framework. Conservation areas are protected as areas of no development while development is limited in Critical Biodiversity areas. Proposals in the SDF are made for two overlay zones which could add legal protection by incorporating these zones in the Municipal Land Use Scheme.	No, Pre SPLUMA SDF. No Critical Biodiversity areas were considered. The SDF does however consider some conservation areas as well as river systems.	

1.4	To what extent does the SDF consider all current and future costs to all parties for the provision of infrastructure services and social services in land development?	The SDF does include chapters on infrastructure provision and its corresponding challenges. It does identify the number of community facilities that would be required to accommodate growth in households over time, but does not address the need for water, sanitation, electricity etc. It also does not quantify the cost of future infrastructure.	The SDF does include chapters on infrastructure provision and its corresponding challenges and provide provides estimates for future social services, but does not address the need for water, sanitation, electricity etc. It furthermore does not quantify the cost of future infrastructure.
1.5	To what extent does the SDF optimise the use of exiting resource and infrastructure?	See 1.2 above. The Municipality has an oversupply of vacant proclaimed erven. The SDF proposes a strict urban edge and financial instruments aimed at limiting sprawl and developing existing vacant stands. The SDF further proposes that future mining activity (located some kilometres away from the main node rather contribute to developing vacant land WITHIN the urban edge as opposed to establishing human settlement far away from the urban core. The SDF also promotes higher densities and infill development as well as spatial targeting for service provision in the rural focus area.	The SDF proposes a strict urban edge aimed at limiting sprawl and developing existing vacant stands.
1.6	To what extent does the SDF make provision for sustainable livelihoods in communities more likely to suffer the impact of economic and environmental shocks?	The SDF focuses on the Agri-Park principle to improve the livelihoods of the poorest communities. Part of the implementation plan furthermore sets objectives for sector departments to ensure the successful implementation of this Agri-Park principle. Informal settlements are ignored.	The SDF mentions that sustainable rural development should be promoted through identifying suitable locations for the development of rural and resource-based industries as well as rural service centres. Except for this statement, however, there is no clear indication how this should be achieved.
1.7	Is the SDF aligned with other sector plans – e.g. WSDP?	No mention is made of the WSDP, nor is there alignment with other water sector related documents.	No mention is made of the WSDP, nor is there alignment with other water sector related documents.
Theme 2. Written and spatial representation of a five-year spatial development plan			
2.1	To what extent does the proposed 5-year spatial form impact on water resources? (does it protect landscapes with high groundwater recharge potential, wetlands, rivers and river buffers)	Rivers, buffers and wetlands are protected through the protection of Critical Biodiversity Areas. This is basically seen as a constraint to development, not really as an environmental resource to be protected. No mention of groundwater recharge potential.	Rivers, buffers are protected through the buffer zones. This is basically seen as a constraint to development. No mention of groundwater recharge potential.
2.2	To what extent does the proposed 5-year spatial form direct development away from ecological infrastructure (e.g. rivers, wetlands, intact green open spaces)?	Yes. Rivers, wetlands, floodplains, environmentally sensitive areas and protected areas are all protected.	The SDF is a pre-SPLUMA SDF, but rivers, wetlands, floodplains, conservation areas are all protected.
2.3	To what extent does the SDFs promote the	No mention of blue-green corridors.	No mention of blue-green corridors.

	development of blue-green corridors inside and outside of built-up areas? (ecological corridors)			
2.4	To what extent does the SDF address the potential impact of the proposed 5-year spatial form on stormwater and does the SDF identify space for the implementation of SUDS or other green infrastructure technologies?	No.	No.	
Theme 3. Spatial Vision				
3.1	To what extent does the SDF have a longer-term spatial vision?	"Ensure sustainable livelihoods for those households residing in the rural areas of the municipality through proper planning, adequate linkage to rural development programs and products while at the same time protecting valuable environmental and agricultural resources"	No	
3.2	To what extent does environmental sustainability (or more specifically water sustainability) a component of this vision?	The vision proposes the protection of valuable environmental and agricultural resources, but does not suggest any link with resource planning, efficiency or sustainability.	No	
Theme 4: Structuring and re-structuring elements				
4.1	To what extent does the spatial structuring elements of the SDF include high groundwater recharge potential, wetlands, rivers and river buffers?	To a certain extent. Once again critical biodiversity areas were included.	To a certain extent.	
4.2	To what extent does the SDF specifically identify the cost or implication of proposed development on the quantity of water?	No. Many of the proposals are for new mining (coal) or Energy Generation. No indication or research as done as to how much water these proposals would consume or any concern expressed as to whether will come from.	No	
4.3	To what extent does the SDF specifically identify the cost or implication of proposed development on the quality of water?	No. Many of the proposals are for new mining (coal) or Energy Generation. No indication or research as done as to the implications on water pollution (either surface or groundwater).	No.	
Theme 5: Estimating Growth				
5.1	To what extent does the SDF provide for a 5-year population growth estimates?	Yes	No, The SDF does however give Household growth estimates	
5.2	To what extent does the SDF indicate any water-related (availability of resources or infrastructure requirements) implications	No	No	

	associated with the 5-year population growth estimate?				
5.3	Does the SDF provide estimates on housing units across different socio-economic categories?	Yes		No	
5.4	If answered yes, does the SDF indicate the planned location and density for the housing units?	Yes		-	
5.6	Are the proposed locations within existing built-up areas?	Yes, although integration between two major nodes are also proposed.		-	
5.7	Will any ecological infrastructure be compromised if and when this development takes place? (FEPAS, CBA's, ESA's and high groundwater recharge areas)	No research was included regarding water recharge areas. In general, development is steered away from Critical Biodiversity areas and Ecological Support Areas. No mention of FEPAS.		No mention of CBA's or ESA's	
5.8	To what extent does the SDF include estimates on economic activities? (Agriculture, mining, manufacturing)	Yes		Yes	
5.9	Does the SDF identify any water-related implications or concerns associated with the specific economic activity? (water demand; water pollution)	No		No	
5.10	If answered yes, does the SDF make any proposals on how to deal with the specific water related issue? (spatial location of mines? Dry crop agricultural practices? Stormwater and effluent discharge regulations?)	No		-	
Theme 6: Engineering services, levels of service and water					
6.1	Does the SDF identify and quantify the requirements of engineering infrastructure and services provision for existing and future development needs for the next five years?	No		No	
6.2	Does the SDF provides for different levels of services (hierarchy) linked to a spatial location? (What is the basic level of services)	Yes - Not all customers can afford to pay for the same level of service, nor can the municipality afford the capital and maintenance burden of providing all customers with the highest possible level of service. It is therefore important to differentiate the level of service to be provided in different areas. In terms of		Yes	

		the Spatial Development Framework, the nodal hierarchy provides these different areas.			
6.3	Does the SDF promote alternative infrastructure as future solutions? (Rainwater harvesting, stormwater harvesting, groundwater utilisation; water reuse)	No		No	
Theme 7: Environmental Assessment					
7.1	To what extent does the SDFs provide for a detailed and strategic assessment of the environmental pressures and opportunities within the municipal area	The land use scheme incorporates the Waterberg Biodiversity Plan		The SDF provides an adequate assessment of environmental pressures	
7.2	To what extent does environmental assessment relate to the protection and sustainable use of water as a resource (e.g. condition of wetlands, rivers, catchments, and groundwater resources?)	The assessment does not specifically make provision or mention of water as a scarce resource that must be protected.		The assessment does not specifically relate to the protection of sustainable use of water as a resource, however the SDF does mention that the availability of water is a major constraint and that it can have an impact on development.	
7.3	Does the SDF provide for a clear delineation of areas where development should be prohibited specifically to protect water resources or ensure that water is not polluted?	No		The SDF does not specifically provide a clear delineation of areas where development should be prohibited specifically related to protecting water and the quality thereof, however the SDF does make provision of river buffers which should not be disturbed by any development.	

Source: Own Construction (2018)

Section 5.3.2.3 provides and in-depth discussion on the key findings the Water Sensitive Compliance Assessment: SDF

5.3.2.2 Water Sensitive Compliance Assessment: LUS

Table 5-4 provides for the Water Sensitive Compliance Assessment conducted for Lephalale and Mogalakwena Local Municipalities LUS.

Table 5-4: Water Sensitive Compliance Assessment: LUS

Water Sensitive Assessment Criteria		Assessment: Lephalale Land Use Scheme 2017	Assessment: Mogalakwena Land Use Scheme 2012
Theme 1: Preparation of Land use scheme			
1.1	During the compilation of the land use scheme, was any water sector department, water utility or waterboard present at the meetings as an interested or affected party?	No	No
1.2	Does the scheme cover the entirety of the municipality? (wall-to-wall land use scheme).	Yes	No. Note however that the municipality is in the process of revising its land use scheme. The intention is to compile a wall-to-wall land use scheme.
Theme 2: Alignment of planning tools			
2.1	Was the scheme revision informed/influenced in any way by the WSDP of the municipality?	No	No
2.2	Are there any linkages between the SDF of the Municipality and the LUS?	Yes – the environmental data identified in the SDF is incorporated as an overlay zone	No. The two instruments in no way align with each other.
2.3	Are sensitive environmental areas protected in some way through the scheme?	Only protected areas (as identified in the South Africa Protected Areas database)	Only protected areas (as identified in the South Africa Protected Areas database). These areas are zoned as “conservation”. The scheme does, however, not consider any sensitive areas that are NOT declared as conservation areas.
2.4	Do these environmentally sensitive areas include any areas specifically related to water? (e.g. FEPA, Ground Water Recharge Zones, Catchment areas etc.)	No.	No.
2.5	Are any of these areas zoned accordingly or “Agriculture” (the typical zoning given to areas outside the urban development boundary)?	No	No – land outside the urban areas are zoned “agriculture”
Theme 3: Zonings, scheme clauses and development controls			
3.1	Does the LUS include any measures to ensure a compact city?	No	No
3.2	Does the existing land use scheme/scheme contain any special considerations (zonings, development	No	No

	controls etc.) specifically focusing on water sustainability?			
3.3	Does the LUS include any development controls to limit the impact on stormwater (e.g. permeable paving etc.)?	No	No	
3.4	Does the scheme contain any clauses/development controls or incentives to promote rainwater harvesting in any way?	No	No	
3.5	Are the maximum size of pools limited in any way?	No	No	
3.6	Does the LUS include any form of alternative zoning (e.g. management overlay or overlay zone etc.) to ensure certain areas are protected from land use activities that may pollute surface and ground water?	Yes. The 1:00 year flood line in the rural area is a management overlay. This though is more to protect the people than the environment.	No.	
3.7	To what extent does the land use scheme provide for any incentives that could promote water sensitive?	None	None	
3.8	Where boreholes are present – are there any protective measures in the scheme to limit any land uses in close proximity that may pollute the borehole and subsequently groundwater?	No	No	
3.9	To what extent does the LUS make provision for mean acquirer recharge zones (areas where groundwater easily penetrates)?	None	None	

Source: Own Construction (2018)

Section 5.3.2.3 provides an in-depth discussion on the key findings the Water Sensitive Compliance Assessment: LUS

5.3.2.3 Empirical Investigation Phase 1.2: Key findings and conclusion

Phase 1.2 of the empirical investigation led to the following key findings:

- Both planning instruments (the SDF and the LUS) are required by law. Both these instruments are key policy instruments informing current and future development. The SDF provides an indication of what type of future development could occur in areas of the municipality and is used in the adjudication of development applications. The LUS however, is the only planning tool that has the force of law and can, therefore, be used to declare development illegal or can be used to enforce certain conditions or requirements on the development before it takes place.
- In both cases, the SDF indicates in some measure where sensitive environmental areas occur. It is clear that the identification of these areas was more a factor of available data (at the time) than a conscious thought to protect natural resources. In fact, more attention is given

to the occurrence of mineral resources (coal in the case of Lephalale, gold in the case of Mogalakwena) than the occurrence and protection of water resources.

- While both SDFs quantify the extent of future development, it falls drastically short to consider the implications of that future development on the availability and quality of water. It would seem as if there is a basic assumption that, no matter what type of development will occur in future, water will always be available to support this type of development.
- There is no alignment between the SDF of the municipality and the WSDP. In fact, in both cases, there is no mention of the WSDP whatsoever. Furthermore, there is no mention of the SDF in either of the two municipality's WSDP (as a component of the IDP). These documents must be aligned to ensure the adequate provision and protection of water resources and the sustainable delivery of water services.
- While many SDF contains the word sustainability and resilience in the vision, only one of the documents provide some indication on how to achieve this. The Lephalale SDF Implementation plan contains several actions for future consideration. Examples include:
 - o Reduce loss of biodiversity and protect ecological areas as part of the municipal land use scheme
 - o Develop a municipal Invasive Alien Plant Control Management Plan which monitors the performance and change actions as necessary.
 - o Appoint a services provider to develop a Lephalale Urban Design Plan which focuses on the integration of urban Blue-green corridors, Water Sensitive Urban Design and City Beautification.
 - o Regulate and promote efficient building design and construction.
- Both LUSs were found completely ignorant of water sensitivity. Water sensitive areas such as FEPA, groundwater recharge zones etc. often occur in the rural hinterland of the municipality. Most often these areas are zoned as "agriculture" without even considering of these areas should be used for agricultural activities, or what the impact would be of these activities.
- It is clear that town and regional planners (such as the researcher) do not have the skills set to deal with issues related to water sensitivity. This is often seen as either an "environmental" subject or an "engineering" one. Skills development in this area is a necessity of water sensitivity is to be considered in these planning instruments.

In conclusion to the Water Sensitive Compliance Assessment, the study recommends that the simple framework should be used to assess all local municipal SDFs and LUSs to determine whether or not there existing and future planning tool address water sensitivity.

Based on the above background information provided for both Lephalale and Mogalakwena Local Municipality in Section 5.3.1.1, Section 5.3.1.2, Section 5.3.2.1 and Section 5.3.2.2, Phase 2 of the empirical investigation will commence in Section 5.4.

5.4 Empirical Investigation Phase 2: Water Sensitive Analysis

Throughout the previous chapters, the study emphasized that the quality and quantity of water resources is largely regulated by the global hydrological cycle. Yet, anthropological interference has significantly altered local water cycles through land-cover change and engineered infrastructure, treating water resource outside of the natural hydrological cycle. The study also identified other anthropological interferences that impact water quality and quantity including:

- i) population growth, urbanisation and uncontrolled rural settlement growth;
- ii) the density, form and location of settlements;
- iii) the levels of services provided;
- iv) economic development trends (e.g. agricultural, mining and industrial activities);
- v) increasing pollution from runoff and inadequate sanitation; and,
- vi) changes to land-use and socio-economic development policies.

All of the above-mentioned factors are affected by the way in which municipalities regulate existing land use and plan for future growth. Thus, the following spatial analysis aims to find new ways through which urban and regional planners can give effect to water sensitivity in preparation of municipal SDFs and LUSs.

To make this empirical investigation feasible within South Africa's existing framework for spatial planning and land use management, the methodology for this empirical investigation adopted the Department of Rural Development and Land Reforms procedural steps required in the process of preparing a municipal SDF (RDLR, 2014b:72) and LUS (RDLR, 2017:35). Based on the above two prescribed processes; this study puts forward a combined or concurrent conceptual process (steps) through which an SDF and LUS can develop (see: Figure 5-7):

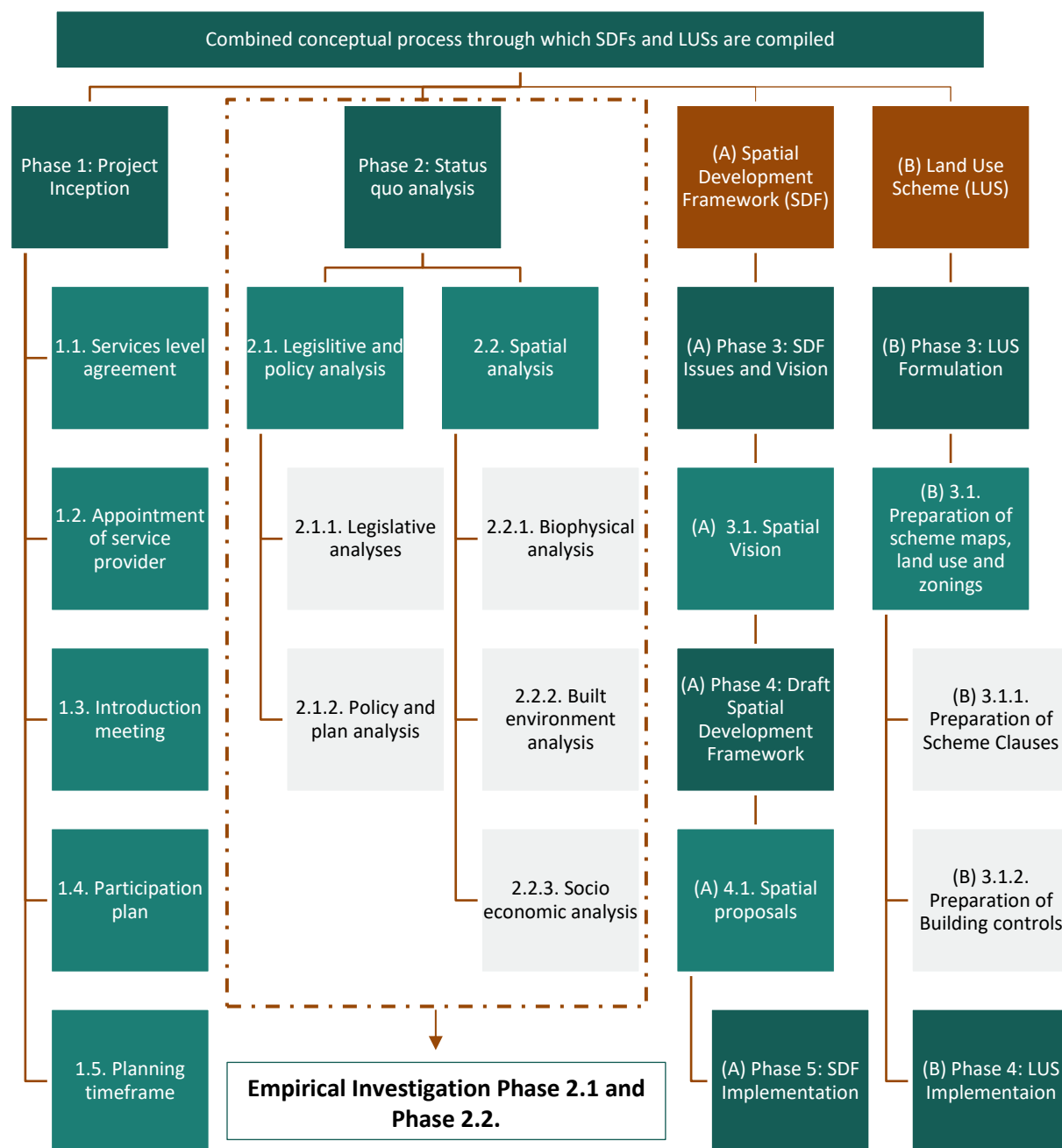


Figure 5-7: A Combined conceptual process for developing SDFs and LUSs

Source: Own Construction (2018) based on RDLR (2014b:72) and RDLR (2017:35)

Note that the focus of the Empirical Investigation Phase 2 focuses on the status quo analysis phase of the combined conceptual process for developing SDFs and LUSs. The information generated in this phase is typically used to inform land use scheme zonings, clauses, building and development controls; and, all future spatial proposals and strategies as contained in an SDF.

Phase 2 of the empirical investigation was conducted according to the schematic presented in Figure 5-8.

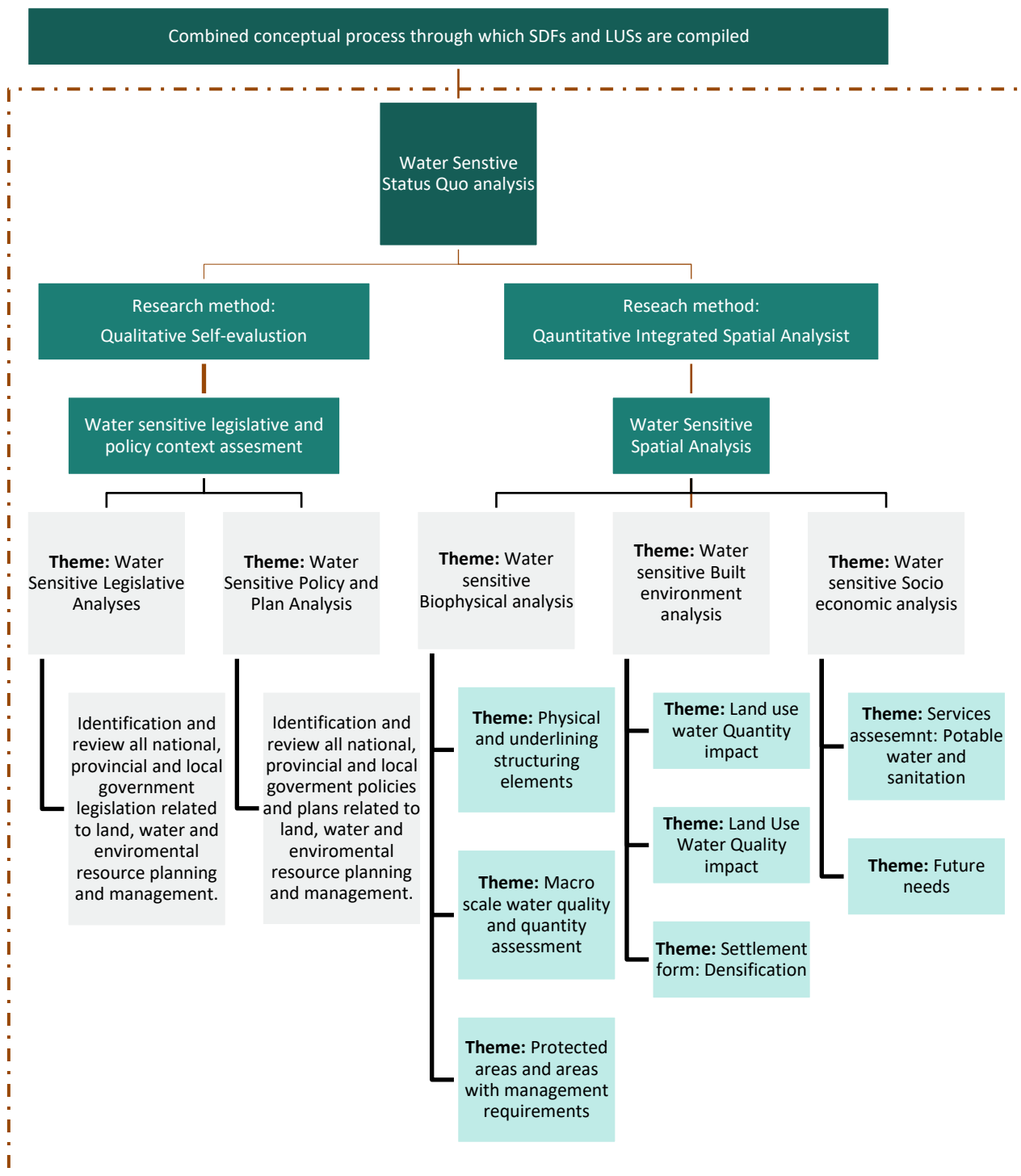


Figure 5-8: Focus of Water Sensitive Analysis

Source: Own construction (2018)

Section 5.4.1 and Section 5.4.2 provides an overview of the design and details of Phase 2.1 and Phase 2.2 of the empirical investigation.

5.4.1 Empirical Investigation Phase 2.1: Water Sensitive legislative and policy context analysis - design and details

The SPLUMA sets out several requirements to which an SDF and a LUS must conform. The SDFs mandate to give effect to and align with national, provincial and local government's legislation, policies and plans is captured in Section 13(3)(a)(b); Section 14(b); Section 15(3)(a)(b)(c); Section 16(a)(c)(f); Section 19(b) and Section 21(i)(m) of SPLUMA. While a municipal LUS has the force of law, it must give effect to and align with national, provincial and local government legislation, policies and plans as set out in section 24 (2)(b); 27(1) and 29(1) of the SPLUMA.

Thus, Phase 2.1 of the empirical investigation applied a thematic self-evaluation assessment of all existing legislation, policies and strategic planning documents adopted in South Africa, that engage with issues affecting land, water and environmental resource planning and management within the selected case study demarcation. The researcher identified and selected 109 documents (legislation, policies, plans) based on their description which may suggest that the document can impose development directives for either land, water or environmental resource planning and management within the selected case study demarcation. The objective of the thematic self-evaluation assessment was to establish a baseline legal and institutional framework for the planning and management of land, water and environmental resources. Whereas the aim was to identify development principles and strategies, regulations norms and standards, visions, goals and if available development targets and other collaborative development initiatives by outlining key spatial informants or directives; and, strengthen the inter-governmental alignment of development priorities and ensure that the plans and programmes are coordinated, consistent and in harmony with each other.

The analysis consists of two high level themes, with several detailed thematic investigations:

- i) Section 5.4.1.1 - Water Sensitive Legislative Analysis
 - **Theme 1:** Identify and review all national provincial, and municipal (selected case study demarcation) legislation relevant to municipal spatial planning, land use, water and environmental resources planning and management;
 - **Theme 2:** Asses each legislation's vision statement and key principles and determine whether they hold any spatial directives applicable to the selected case study municipalities;

- **Theme 3:** Identify and assess the roles and responsibilities mandated to various spheres of government or responsible authorities relating to land, water and environmental resource planning and management;
- **Theme 4:** Identify any regulations published in terms of the above identified legislation which sets out norms and standards which holds development implications or opportunities.
- **Theme 5:** Identify any policies, strategies, frameworks and/or guidelines published in terms of the above identified legislations and list them for further discussion (see Annexure A for detailed further detail).

ii) Section 5.4.1.2 - Water Sensitive Policy and Plan Analysis

- **Theme 1:** Identify and review all national, provincial and local government (selected case study demarcation) policies relevant to municipal spatial planning, land use, water and environmental resources planning and management;
- **Theme 2:** Assess each policy's vision statement and key principles and determine whether they hold any spatial directives applicable to the selected case study municipalities;
- **Theme 3:** Assess the aims, objective and targets (if any) relating to land, water and environmental resource planning and management.
- **Theme 4:** Identify and review all strategic sector plans (water, environmental, economic, transportation, energy etc) adopted by the national and provincial departments (relevant to the selected case study demarcation) and assess the spatial and water related impact thereof on the two selected case study municipalities.
- **Theme 5:** Assess the vision, mission, objective and desired outcome of the plans.
- **Theme 6:** Identify and review development principles of each plan and highlight any spatial directives applicable to the selected case study municipalities (see Annexure C for detailed further detail).

Section 5.4.1.1 and Section 5.4.1.2 reveals the findings of the Water Sensitive Legislative Analysis and Water Sensitive Policy and Plan Analysis. Section 5.4.1.2 reflects on the findings of the phase 2.1 of the empirical investigation.

5.4.1.1 Water Sensitive Legislative Analysis

This section provides a summary of various national, provincial (Limpopo Province) and local government (Waterberg District Municipality; Lephalale and Mogalakwena Local Municipality) legislation, reviewed and analysed during Phase 2.1 of the empirical investigation to gain a better understanding of South Africa's broader-scale land, water and environmental resource planning and management context. The Water Sensitive Legislative Analysis identified 13 national legislations that engage with land, water or environmental resource planning and management either directly or indirectly. Table 5-5 provides a summary of all national legislation's vision statement, aim, key principles and spatial directives imposed on land, water or environmental resources planning and management. It also lists several policies and plans to be prepared by National, Provincial or local government department, which in theory can give effect to WSSP.

Table 5-5: Case study analysis into national legislation applicable to WSSP

Vision /Aims/ Key principles	Development directives land / water / environment	Policies and plans	Existing policies and plans applicable to the study
The Constitution Act no. 108 of 1996			
The constitution is South Africa supreme law and provides for a constitutional system where the executive powers and functions of government regarding functional areas reside in the three different spheres of government. All decision-making processes should promote the principle of dignity and equality.	The bill of rights enshrines the right of all people in terms of section 24, to an environment that is not harmful to their health and well-being; Section 26, to housing ; and Section 27(b) to sufficient food and water . Furthermore, section 152 set the objective of local government to ensure access to at least basic services and facilitate economic development within a framework of financial sustainability.	The constitution calls for legislative and other measures to be prepared and implemented within available resources, to progressively achieve each of these rights.	n/a
Municipal Systems Act no. 32 of 2000			
The aim of the Act is to establish a framework for integrated planning to enable municipalities to move progressively towards the social and economic upliftment of local communities and ensure universal access to essential services that are affordable to all and is environmentally sustainable.	Section 11(3) allows a municipality to develop and adopt policies, plans, strategies and programmes, including- setting targets for delivery; promoting and undertaking development; and, providing municipal services to the local community. All of the above will impose some land, water or environmental resource related implications. Chapter 5 establishes a platform for municipal integrated planning and co-operative governance by means of an IDP.	All districts and local municipalities must prepare a Municipal Integrated Development Plan (S.5).	Waterberg District IDP 2017-18
			Lephalale IDP 2018-19
			Mogalakwena IDP 2018-19
Local Government: Municipal Finance Management Act no. 56 of 2004			
The Act aims to secure sound and sustainable management of the financial affairs of municipalities and other institutions in the local sphere of government.	The Act requires all local municipalities to prepare budgets to allocate funding towards land, water and environmental management projects. Where, when and how municipal budgets is spent affects both water resource quality and quantity directly. A lack of financial investment in land and environmental rehabilitation can also lead to the physical loss of ecological infrastructure.	All district and local municipalities must prepare Service Delivery and Budget Implementation Plans (S.53(1))	Waterberg Service Delivery and Budget Implementation Plan 2017-18
			Lephalale Service Delivery and Budget Implementation Plan 2017-2018
		All district and local municipalities must prepare Medium-Term Revenue and Expenditure Framework (S.16(2))	Waterberg Budget Plan as part of the IDP Chapter 19 Lephalale Draft budget 2018-2019
Spatial Planning and Land Use Management Act no. 16 of 2013			
The vision of SPLUMA is to "promote social and economic inclusion; provide for the efficient use of land; redress	The Act sets clear spatial directives impacting on land, water and environmental resources which includes	National government must adopt a National SDF (S.13);	Draft National Spatial Development Framework

the imbalances of the past and ensure that there is equality in the application of spatial development and land use management". It aims to restructure South African cities, towns and settlements are in line with priorities and principles of the democratic government.	achieving spatial justice; spatial sustainability; efficiency and spatial resilience. The Act also clearly states that spatial planning and land use management decisions must minimise negative environmental impact and take cognisance of any environmental management instrument adopted by the relevant environmental management authority. Urban planners must, therefore, consider the availability and quality of existing water resources and propose and implement land use management principles to address the current and future water quality and quantity impact of development. Furthermore, land development must optimise the use of existing resources and infrastructure and provide direction for infrastructure development. The condition of infrastructure must, therefore, be considered when development applications are decided on.	All 9 provincial governments must adopt a Provincial SDF (S.15)	Limpopo Provincial Spatial Development Perspective
		The minister or MEC may call for the development of a Regional SDF (S.18)	Waterberg District Spatial Development Framework
		All local municipalities must adopt a municipal SDF (S.20)	Lephalale Spatial Development Framework 2016
			Mogalakwena Spatial Development Framework 2009
		All local municipalities must adopt a Municipal Land Use Scheme (S.23)	Lephalale Land Use Scheme 2017 Draft 2012 Mogalakwena Land Use scheme
National Water Act no. 36 of 1998			
The vision of the NWA is to provide some "water" for all, forever. The Act aims to ensure that South Africa's water resources are protected, developed, controlled, conserved, managed and used in a sustainable manner, for the benefit of all. The act also gives effect to the Constitutional right that everyone has the right to an environment which is not harmful (Section 24 Act 108 of 1996) and sufficient water (Section 27(b) Act 108 of 1996). The act promotes the use of water in the public interest in such a manner that it is beneficial for the achievement of equitable and sustainable economic and social development.	The act calls for IWRM which considers the class of water resources, resource quality objectives and the reserves as contemplated in Chapter 3, focusing on the protection of water resources. The act also states that where pollution of a water resource occurs or might occur as a result of activities on land, the person who owns, controls, occupies or uses the land in question is responsible for taking measures to prevent pollution of water resources. The act also states that the Minister may differentiate between water resources, classes of water resources and geographical areas and limit the amount of water the responsible authority may allocate.	The minister must adopt a National Water Resource Strategy (S.5) also to address groundwater (National groundwater strategy)	National Water Resource strategy 2013 National Groundwater strategy 2016
		Each CMA must adopt a Catchment Management Strategy (S.8)	Limpopo Water management Area North Reconciliation Strategy 2016 (not a CMS, but close enough).
Water Services Act no. 108 of 1997			
The aim of the WSA is to provide efficient, equitable and sustainable	The Act sets national norms and standard for service provision relating to a minimum level of basic water	All Local Municipalities Must prepare a Water Services	Lephalale WSDP 2014 As part of IDP Chapter 5

access to basic water supply and sanitation services which are not harmful to the environment. Together with the NWA, the WSA also gives effect to the Constitutional right of sufficient water (Section 27(4)).	supply and basic sanitation and provides a tariff structure which allows for a certain volume of free water for all: National norms and standard target – 25l of free potable water pp/per day; within 200m of a household, and basic sanitation which is anything but a bucket toilet. The Act also sets the regulatory framework for water services institutions and water services intermediaries.	Development Plan (WSA) (S.12)	Mogalakwena WSDP 2010/20112014 As part of IDP Chapter 4
National Environmental Management Act no. 107 of 1998			
The Act aims to secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development to reduce inequality. The Act puts in place the principle of polluter pays; precautionary principle; environmental justice and integrated environmental management; community participation and empowerment. The act also gives effect to the Constitutional right to a healthy environment (Section 24).	This law and its requirement for sustainability are relevant to all sectors of government and service provision. Section 24 of NEMA stipulates that an Environmental Impact Assessment (EIA) is required for activities which could have a significant impact on the environment (NEMA, 1998). Section 24 of NEMA, together with regulations on Environmental Impact Assessments (EIA regulations) and regulations on Environmental Management Frameworks (EMF Regulations), deals with environmental authorisations. The Act also provides for biodiversity offsets as a condition attached to EIA. EIA Regulations include R 543, R 544, R 545, R 546, R982, R983, R984 and R985 list all in all 121 activities which are subject to an Environmental Impact Assessment. EMF regulations include R 574.	The Minister must prepare a National Environment Outlook Report (S.16)	National Environmental Outlook Report 2016
		The Minister must prepare a National Environmental Management Framework (S. 24(2))	Absent
		Listed department and institutions must adopt Environmental Management Plans (S.11 (1))	Absent
		Listed department and institutions must adopt Environmental Implementation Plans (s. 11 (2) & 16)	Limpopo Environmental Implementation Plan 2015-2020
		Provinces must prepare Provincial Environment Outlook Reports (s. 16)	Limpopo Environmental Outlook Report 2016
		Municipalities may adopt Environmental Management Framework (s.24(2)(3))	Waterberg District Environmental Management Framework Report
National Environmental Management: Biodiversity Act no. 10 of 2004			
The act aims to provide for the management, conservation, fair and equitable sharing of biological diversity. It aims to give effect to international agreements relating to biodiversity and to provide for co-operative governance in terms of environmental resource management. The principles of this act are embedded in as per section 2 of the	The Act calls for the sustainable management, conservation and protection of ecosystems that warrant national protection. Through systematic biodiversity planning the Act guides the development of planning tools to be used for protecting and managing both land, water and environmental resources.	The minister must develop a National Biodiversity Framework (NBF) (s. 39) to be informed by National Biodiversity Assessment (As per NBF) and National Biodiversity Strategy and Action Plan (As per NBF)	National Biodiversity Framework 2008
			National Biodiversity Assessment (NBA) 2018
			2nd National Biodiversity Strategic Action Plan 2015-2025
		All Provinces must prepare Provincial Spatial	Absent

National Environmental Management Act		Biodiversity Plans (As per NBF (Priority action 16))	
		Provincial government may adopt Provincial conservation plans (As per NBF)	Limpopo Conservation Plan v2 CBAs 2013
		The minister may declare areas as bioregions that requires for bioregional plans to be prepared (As per NBF Priority action 17))	Waterberg District Bioregional Plan 2016
National Environmental Management: Protected Areas Act no. 57 of 2003			
The act provides for the declaration and management of protected areas to preserve the ecological character of such areas and to give effect to a national system of protected n state land, private land and communal land areas. The Act also promotes sustainable utilisation of protected areas and co-operative governance.	The 2016 National Protected Areas Expansion Strategy sets a 20-year target to increase the countries protected areas network by 255 877 km ² consisting of 104 962 km ² marine benthic and coastal ecosystems; 146 814 km ² terrestrial ecosystems; 2 352 km² wetlands; and 1 490 km² rivers.	All legally declared protected areas must implement a Protected Areas Management Plan (S. 39)	Limpopo Nature Reserve Protected Areas Management Plans 2013
Disaster Management Act no. 57 of 2002			
This act aims to integrated and coordinated disaster management policy in South Africa that focuses on preventing and reducing the risk of disasters, mitigating the severity of disasters, emergency preparedness, rapid and effective response to disasters and post-disaster recovery.	The act defines a disaster as a progressive or sudden, widespread or localised, natural or human-caused occurrence which causes damage to property, infrastructure, or the environment. As this act aims to prevent disasters, it requires all national and provincial organs of state as well as all metropolitan and district municipalities to prepare a disaster management plan which identifies and maps risks, areas, ecosystems, communities and households that are exposed or vulnerable to physical and human-induced threats. Freshwater ecosystems, river and wetland buffers, areas most likely to be affected by drought and flooding should thus be identified spatially and included in the maps.	The minister must adopt a National Disaster Management Framework (NDMF) (Section 6) accompanied by a National Disaster Management Plan.	National Disaster Management Framework (2005)
		Each national organ of state and all provinces must prepare a Disaster Management Plan (Section 25 & 39) for its functional area.	Absent
		Each metropolitan and each district municipality must adopt a Disaster Management Plan (S.42 & S.53)	Waterberg District Disaster Management Plan 2014
National Environmental Waste Act no. 59 of 2008			
The act seeks to reduce the amount of waste that is generated and, where	The act seeks to reduce consumption of natural resource - this means reducing the amount of water	National Waste Management Strategy (S.6)	National Waste Management Strategy 2011

waste is generated, to ensure that waste is re-used, recycled and recovered in an environmentally sound manner before being safely treated and disposed of.	consumed which has a direct impact on water resource availability. The act also calls for increased waste recovery, prevent pollution and ecological degradation . The spatial location of human activities and more specifically the location of waste disposal sites may impose groundwater and surface water quality implications .	Provincial Integrated Waste Management Plan (S.11(1))	Absent
		Municipal Integrated Waste Management Plan (S.4(a) as a component of the IDP)	(Chapter of IDP?)
National Housing Act 107 of 1997			
The Act provides for facilitation of sustainable housing development process and lays down general principles applicable to housing development – which states that housing development must be affordable, sustainable, environmentally friendly and culturally diverse.	Of specific importance to this study is the fact that the Act requires all housing development to consider and address its impact on the environment and facilitate higher density development . Furthermore, the act states that every municipality must take reasonable steps to ensure that services in respect of water, sanitation and stormwater are economically efficient .	The minister must adopt a National Housing Code (S. 4(1)) accompanied by a Comprehensive Housing Plan (S.4 (c))	National Housing Code (2009)
			Development of Integrated Sustainable Human Settlements (Breaking New Ground)
		The provincial government must develop a Provincial Housing Policy and multi-year Housing Sector Plan (S.7(2)(g))	Absent
		Each municipality must develop a Municipal Housing Sector Plan (S. 9)	Absent
National Land Transportation Act no. 5 of 2009			
The Act aims to transform and restructure the national transport system by prescribing national principles, requirements, guidelines, frameworks and national norms and standards.	Amongst the Acts principles, the Act discourages urban sprawl and gives priority to infilling and densification along public transport corridors . The Act states that any measure relating to public transport must promote the efficient use of energy resource and limit adverse environmental impacts in relation to land transportation.	The minister must develop a National Land Transport Strategic Framework (S.34)	National Land Transport Strategic Framework (2017-2022)
		All province must prepare a Provincial Land Transportation Framework (S. 35)	Provincial Land Transport Framework for the Limpopo Province (2012)
		District municipalities must prepare District Integrated Transportation Plan (S.36)	District Integrated Transport Plan (DITP) 2015
		Local municipalities must prepare Municipal Integrated Transportation Plan (S. 36)	Lephalale ITDP as part of IDP Chapter 5 Mogalakwena ITDP as part of IDP Chapter 8

Source: Own construction adopted from South Africa (1996a); South Africa (2000); South Africa (2004b); South Africa (2013); South Africa, (1998a); South Africa (1997a); South Africa (1998b); South Africa (2004a); South Africa (2003); South Africa (2002); South Africa (2008); South Africa (1997b) and South Africa (2009).

Provincial legislation and municipal by-laws are unique to each province and municipality. Regarding provincial legislation, only two, the Limpopo Environmental Management Act 7 of 2003 and the Limpopo Housing Act no. 2 of 2006 were found relevant to the study. Table 5-6 summarises how each provincial by-law affects land, water and environmental resource planning and management on local municipal level (demarcated to the selected case study areas).

Table 5-6: Case study investigation into provincial legislation applicable to WSSP

Vision /Aims/ Key principles	Development directives land/water/environment	Policies and plans	Existing policies and plans
Limpopo Environmental Management Act no. 7 of 2003			
The objective of the Act is to manage and protect the environment in the province to secure ecologically sustainable development and responsible use of natural resource in the province. This act, together with the all other national environmental management acts gives effect to the Constitutional right to a healthy environment.	This Act, together with the National Protected Areas Act grants the MEC the power to declare areas of land within the province as a Provincial Nature Reserve, a Site of Ecological Importance, a Protected Environment, a Private Nature Reserve or a Resource use area. The MEC may also declare an area of land as a limited development area, and/or a mountain catchment area. These areas should include areas with high groundwater recharge potential, high surface water runoff potential and all other freshwater ecosystem priority areas.	The act does mandate for the preparation of any additional policies or plans	n/a
Limpopo Housing Act no. 2 of 2006			
The object of this Act is to promote and facilitate housing development in the province within the framework of national legislation and the national housing policy. The principles of this act echo those of section 2 of the Housing Act.	The Act encourages the Limpopo Provincial Housing Agency to develop new and innovative ways of reducing the cost of housing development and diversify the type of design and layout used in provincial projects. The design should include decentralised wastewater treatment works, rainwater harvesting and water reuse technologies. The Limpopo Housing Act also allows municipalities to be accredited for the purpose of administering one or more housing programmes.	The act does mandate for the preparation of any additional policies or plans	n/a

Source own creation adopted from Limpopo Provincial Government (2003) and Limpopo Provincial Government (2006)

Lephalale Local Municipality promulgated several by-laws including the Lephalale Spatial Planning and Land Use Management By-law, the Lephalale Local Municipality Water and Sanitation Services By-law (2005); Lephalale Local Municipality Stormwater By-law (2011); and the Lephalale Local Municipality Waste Management By-Law (2011). Table 5-7 presents a summary of how each of Lephalale's adopted by-laws affect land, water and environmental resource planning and management within the municipality.

Table 5-7: Case study investigation into Lephalale Local Municipality by-laws applicable to WSSP

Vision /aims/ Key principles	Development directives land/water/environment	Policies and plans	Existing policies and plans
Lephalale Spatial Planning and Land Use Management By-law			
The by-law echoes the principles of the Act no. 16 of 2013	The by-law echoes the development directives as per SPLUMA. Regarding the future planning of land, the by-law states that a municipal SDF does not confer or take away land use rights but guides and informs decisions to be made by the Municipality relating to land development. In addition to Section 25 of SPLUMA, this Act states that a land use scheme should promote harmonious and compatible land use patterns; aesthetic considerations; and, sustainable development and densification.	The municipality may determine any further plans, policies and instruments by virtue of which the municipal spatial development framework must be applied, interpreted and implemented s(5). The municipality may adopt a local spatial development framework for a specific geographic area of a portion of the municipal area (precinct plans) S10(1)(a).	Absent
Lephalale Local Municipality Water and Sanitation Services By-law (2005)			
The municipality recognises that all consumers have the right of access to basic water supply and basic sanitation and the areas of jurisdiction of the municipality within an environment not harmful to human health or wellbeing.	The Act allows the Municipality to determine service levels, differentiate between types of consumers, geographic areas and socio-economic areas. Furthermore, section 8(3) of the by-law states that no development may take place on any premises unless the Municipality has installed a connection pipe and meter. Regarding the environment, section 18 states that a person may in any manner pollute water or the environment in the jurisdiction of the municipality including but not restricted to all water source such as streams, rivers, and dams. The bylaw also grants the municipality the right to impose water restrictions section 20.	Water Services Development Plan	Absent
Lephalale Local Municipality Stormwater By-law (2011)			
The purpose of this by-law is to regulate stormwater management and activities at which may have an adverse impact on the development, operation and maintenance of the stormwater system.	The Act states that no person may change the design or the use of, or otherwise modify any feature of the stormwater system which alone or in combination with other existing or potential land use, may cause an increase in flood levels or create a potential flood risk.	The by-law states that if a person wishes to obtain municipal consent as contemplated in section 3, the municipality may request that the applicant undertake an impact assessment, environmental impact studies or environmental impact investigation as required by environmental legislation.	Absent
Lephalale Local Municipality Waste Management By-Law (2011)			

The by-law echoes the principles of the Act no. 5 of 2009	The by-law addresses the management and solid waste within the municipality. Regarding land, the bylaw imposes several requirements and restrictions as to where waste related activities can take place . Regarding water and the environment, the by-law states that no person may dump, accumulate, place, deposit, leave or cause dumping in any drain, watercourse, flood-prone areas, tidal or other waters to which the public has access to.	the municipality must include a waste management plan as part of the IDP s. (4)	Absent

Source own creation adopted from Lephalale Local Municipality (2005); Lephalale Local Municipality (2011a) and Lephalale Local Municipality (2011b).

Mogalakwena Local Municipality promulgated a Water-by Law and a Spatial Planning and Land Use Management By-Laws in 2016. Table 5-8 provides a summary of how each of Mogalakwena's adopted by-laws affect land each by-law affects land, water and environmental resource planning and management within the municipality.

Table 5-8: Case study investigation into Mogalakwena Local Municipality by-laws applicable to WSSP

Vision /aims/ Key principles	Development directives land/water/environment	Policies and plans	
Mogalakwena Spatial Planning and Land Use Management By-Laws in 2016			
The by-law echoes the principles of the Act no. 5 of 2009	Similar to that of the Lephalale by-law, Mogalakwena's by-law also echoes the development directives as per SPLUMA. In addition to Section 25 of SPLUMA, this Act states that a land use scheme shall make provisions applicable to all properties relating to stormwater. This presents the municipality with an opportunity to implement SuDS as an alternative to conventional stormwater infrastructure.	Chapter 2 of Mogalakwena's SPLUMA by-law mandate the development of a municipal spatial development framework in accordance with the provision of section 20 and 21 of Act no. 16 of 2013.	Mogalakwena Spatial Development Framework 2009
		Section 15 also mandates the development of a municipal land use scheme in accordance with the provision of section 24 and 30 of Act no. 16 of 2013.	Draft 2012 Mogalakwena Land Use scheme
		Section 10 of the By-law also states that the Municipality may adopt a local spatial development framework for a specific geographic area.	Absent
Mogalakwena Local Municipality Water-by Law 2006			
The purpose of this by-law is that water services are supplied for purposes specified in the agreement.	In terms of Section 13 of the by-law, the Council may limit or discontinue services if	The act does mandate for the preparation of any additional policies or plans	n/a

	there is environmental damage or water pollution. In term of sanitation services, the by-law states that - to construct, install, maintain or operate any septic tank or other plant for treatment, disposal or storage of sewage, council must give prior written permission; Council may permit disposal of wastewater or other effluents by means of a French drain, soakage pit or other approved work; permit owner of premise to construct a conservancy tank and permit the disposal of human excrement by means of a ventilated improved pit latrine.		

Source: Own Creation (2018) adopted from Mogalakwena Local Municipality (2016) and Mogalakwena Local Municipality (2006)

According to the Water Sensitive Legislative Analysis, national legislation mandates national government departments to develop and adopt approximately 9 different national policies and strategic plans to guide sustainable resource planning and management. Several of which are currently in place, while others still need to be developed. Section 5.4.1.2 provides for a comprehensive analysis on how the nationally mandated existing policies and plans affect municipal level land, water and environmental resource planning and management.

5.4.1.2 Water Sensitive Policy and Plan Analysis

In addition to the mandated policies and plans, the National Development Plan: Vision 2030; Medium-Term Strategic Framework 2016-2019; and the Integrated Urban Development Framework should be used to inform strategic development on local government level. National government also obligated to give effect to two international agendas including the Sustainable Development Goals 2030 and the African's Union Agenda 2063. Both agendas are target orientated strategies.

Table 5-9 provides for a summary of all national policies and plans relevant to the study. The summary focuses on the national objective and targets which can be achieved through water sensitive spatial planning and land use management.

Table 5-9: Case study analysis into national policies applicable to WSSP

Key development directive	Relevance to the study	How does the plan affect local municipal land, water and environmental resource planning and management?
The 2030 Agenda for Sustainable Development		
The SDG maps a new pathway to a better future and sets several development goals in place. • Goal 6 stipulates “to ensure the availability and sustainable management of water and sanitation for all” • Goal 11 stipulates that we should “make cities and human settlements inclusive, safe, resilient and sustainable” • Goal 13 stipulates that “take urgent action to combat climate change and its impacts” • Goal 15 stipulates “protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat densification, halt and reverse land degradation and halt biodiversity loss”.	Gaol 6, targets, by 2030: • achieve universal and equitable access to safe and affordable drinking water for all; • ending open defecation; • halving the proportion of untreated wastewater; • substantially increasing recycling and safe reuse globally By 2020: • protect and restore water-related ecosystems; Goal 11, targets by 2030: • ensure access for all to adequate, safe and affordable housing and basic services; • substantially decrease the direct economic losses relative to the global gross domestic product caused by water-related disasters; • reduce the adverse per capita environmental impact of cities; • provide universal access to safe, inclusive and accessible, green and public spaces; Goal 13, targets by 2030: • strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries; • integrate climate change measures into national policies, strategies and planning; Goal 15; targets, by 2020: • ensure the conservation, restoration and sustainable use of inland freshwater ecosystems and their services is in line with obligations under international agreements By 2030: • combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land-degradation-neutral world	✓ Lephalale and Mogalakwena Local Municipality should eradicate all water services backlogs; ✓ strategic focus should be on upgrades and servicing settlements with off-grid and dry sanitation solutions in areas where services are lacking or non-existing; ✓ WSUD should be used to treat stormwater runoff and wastewater before discharge into natural water bodies; ✓ Housing projects funded by Government should make provision to include dual pipe water treatment networks. Municipal building controls should incentivise private developers for including reuse and recycling technologies in buildings. ✓ SDF should direct development away for ecologically sensitive areas while the municipal land use schemes should use a protective overlay zone to legally protect these ecosystems; ✓ (the spatial location of future housing projects has both water quality and quantity impact. Locating these households close to existing infrastructure networks or as infill development projects will lower the UARL volume, while decentralised wastewater treatment systems (SUDS) should also be included in the housing layout to improve water quality; ✓ Droughts and floods should be planned for – alternative source of water (water reuse, groundwater and rain/stormwater harvesting should be part of the municipalities daily water supply source; developments close to, or on water source areas should be prohibited as far as possible while natural vegetation should be in good ecological condition close to these; ✓ The environmental impact can be reduced by limiting urban sprawl through infill development and densification strategies; WCDM strategies; and through city greening and beautification strategies; ✓ Localised spatial accessibility analysis should inform this target; these areas should also be used for multifunctional purposes such as retention or detention ponds, constructed wetlands and recreational purposes – spatial planning should inform this target; ✓ Increase the natural vegetation in settlement areas, protected ecological sensitive areas; reduce greenhouse gas emissions by making cities more compact, reducing travel time, and by resorting to green alternative technologies such as solar panels

		and rainwater harvesting for non-potable purposes (ultimately reducing energy demand and water demand; ✓ this should also form part of local municipal strategies and policies specifically the municipal; ✓ On a local municipal level, freshwater ecosystems can be protected by law through a Municipal Land Use Scheme while the sustainable use should be regulated through municipal WCDM or tariff increase or water reuse schemes; ✓ The municipal SDF should limit urban expansion and encourage infill development while also protecting and rehabilitating existing open spaces.
African Unions (AU) Agenda 2063		
The AU Agenda reflects the desire for shared prosperity and well-being, for unity and integration, and for a continent of free citizens. The Agenda sets 7 aspirations with supplementary goals. Amongst the aspirations: • Aspiration 1 calls for “a prosperous Africa based on inclusive growth and sustainable development.”	Aspiration 1, goals, by 2036: • African people have a high standard of living; • Cities and other settlements are hubs of economic activities, with modernized infrastructure, and people have access to affordable and services including water & sanitation.	✓ Living standards are determined by a person’s level of access to services – improving the level of access to household services should be informed by financial and environmentally sustainable measures – the spatial location of settlements can be used as a measure to determine whether the level of services is sustainable. ✓ Modernised infrastructure should also include green infrastructure such as constructed wetlands to harvest and treat stormwater, large-scale rainwater harvesting tanks and decentralised water reuse systems; dual pipe water distribution systems etc. – the spatial layout and property rights is a major determining factor in the above.
National Development Plan & National Infrastructure plan		
By 2030, South Africa’s transition to an environmentally sustainable, climate-change resilient, low-carbon economy and just society will be well underway.	Water-related NDP targets, by 2030: • Ensure that all people have access to clean, potable water and that there is sufficient water for agriculture and industry, recognizing trade-offs in the use of water • Reduce the water demand in urban areas to 15% below business as usual scenario by 2030 Spatial and planning related targets, by 2030: • Resilient planning is integrated into all planning processes in the country; • South Africa has a strong and efficient spatial planning system, well integrated across the spheres of government; and, • All informal settlements have been upgraded and are positioned on suitable, well-located land.	✓ Local municipalities should address all water services backlogs and leapfrog towards alternative solutions or source to address the demand; ✓ Spatially, the study already indicated that higher density developments have a lower UARL volume which could contribute to the 15% reduction in water use. The municipality could introduce building controls for to regulate all new development application or brownfield development to enforce the use of water savings technologies (building can save up to 30% of water use) as a prerequisite for any development approval; ✓ Resilient planning should be integrated into local municipal planning processes – this should include environmental, social, cultural, economic and financial resilience; ✓ Alignment between SDF, LUS, Bioregional Plans, WSDP and IDP is critical in this regard; ✓ Municipal spatial planning and land use management should allocate new stands close to existing urban hubs, infrastructure networks, and away from ecologically sensitive areas;

Medium Term Strategic Framework 2014-2019		
By 2030, South Africa's transition to an environmentally sustainable, climate-change resilient, low-carbon economy and just society will be well underway. The MTSF focuses on the creation of a framework for implementing the vision of the NDP. The MTSF has two overarching themes, one of which is improving services delivery. The MTSF 2014-2019 has 14 outcomes with detailed targets. Outcome (6) efficient, competitive and responsive economic infrastructure; (7) Vibrant, equitable, sustainable rural communities contributing towards food security for all, (8) Sustainable human settlements and improved quality of household Life; (9) Responsive, accountable, effective and efficient developmental local government system; (10) Protect and enhance environmental assets and natural resource all engage with some form of land, water and environmental resource planning and management.	Water-related Targets, by 2019: 1. Have a 5% increase in bulk water resources commissioned in comparison to 2014; - Increase in the percentage of households with access to functional water service from 85% in 2013 to 90% by 2019; Human settlement targets, by 2019: - Adequate housing and improved quality living environments, with 1.495 million more households living in new or improved housing conditions by 2019; - Informal settlement upgrading will be expanded to cover 750 000 households, ensuring basic services and infrastructure in some 2 200 informal settlement; Environmental resource related targets, by 2019: - Stabilisation and reduction of CO₂ (a 34% reduction in emissions of CO₂ from "business as usual" by 2020 (42% by 2025) - Increasing the compliance of mines with the National Water Act from 35% in 2013 to 60% in 2019	✓ Municipal SDF should provide spatial guidance on where bulk water resource should be commissioned; ✓ Non-functioning water services can result due to a lack of maintenance – the should be addressed by the municipalities asset management plan, new developments in areas where water services in non-functioning should also be prohibited; ✓ The spatial location of these houses should not encourage sprawl but rather infill development and densification; ✓ Refer to the above and green infrastructure should be prioritised green or alternative infrastructure solutions in these informal settlements; ✓ The municipality can reduce greenhouse gas emissions by making cities more compact, reducing travel time, and by resorting to green alternative technologies such as solar panels and rainwater harvesting for non-potable purposes (ultimately reducing energy demand and water demand; ✓ Mining-related activities are very popular in both Lephalale and Mogalakwena Local municipality due to the mineral resource – the municipality should play a regulatory role in this regard).
Draft National Spatial Development Framework (2050)		
The National SDF gives effect to the SPLUMA principals which include amongst others spatial justice; spatial sustainability; spatial resilience; and, spatial efficiency. The NSDF Vision recognises the foundational value of South Africa's shared natural resources and national ecological infrastructure by stating that the "Restoration and management of national freshwater bodies and strategic water source production areas is of critical importance for (1) water availability, (2) national well-being, (3) food security, and (4) sustainable economic development. These areas form part of ecosystem service areas that:	Frame 3: National Ecosystem Resource Protection Areas - Declare new protected areas, e.g. parts of the Strategic Water Source Areas could be considered as Nature Reserves or Protected Environments through the Protected Areas Act (Act 57 of 2003). - Strategic Water Resource Management Regions - Land-uses that reduce stream flow or affect water quality (e.g. mining, plantations, overgrazing) should be avoided in SWSAs, wetlands should be kept in good condition or rehabilitated, and invasive alien plants should be cleared. - Formal protection of SWSAs should be strengthened, for example through declaring parts of these areas Nature	✓ This should also be identified on local municipal level through the SDF and protected legally through the LUS. ✓ All of the above-described areas should be identified spatially through the SDF – to be used to inform other municipal strategies such as green job creation or city beautification projects; ✓ SWSAs in local municipalities should be protected as far as possible through spatial planning and land use management tools; ✓ Decentralised wastewater treatment infrastructure must be incorporated into all new development's layouts in support of large-scale and small-scale water recycling projects. Dual-pipe reticulation systems should form part of building controls and regulations for all new developments and urban rejuvenation projects. ✓ Water efficiency should be the main priority in all local municipalities. Land use water audits (see later section) Should

• Support long-term ecological functioning at the landscape level (which in turn supports climate change adaptation); and • In some cases, constitute ecological infrastructure that provides valuable ecological services directly to people”. Frame Three: National Ecological Infrastructure System as Enabling Infrastructure for a Shared and Sustainable Resource Foundation Frame 4: National Connectivity and Economic Infrastructure Networks as enabling infrastructure for a shared, sustainable and inclusive economy Frame Five: National Social Service Infrastructure System as Enabling Infrastructure for National Well-being	reserves or protected environments (Protected Areas Act (Act 57 of 2003)) Frame 4: Infrastructure to support water security and flows • Dams must be built, expanded or maintained to enhance water storage under conditions of climate change. Water recycling must be practised in all urban cores and regional anchors/growth regions. • Water pipelines must be maintained and extended to key urban cores, anchor towns and geo-specific production sites in line with national priorities and/or trade-offs. Water efficiency is critical action for sustainability, which requires the prioritisation of water recycling, management and augmentation projects Frame 5: Consolidated settlement development and growth • Limited new growth or development in human settlements, especially in arid parts of the country. Especially in the drier west, but applicable to all low-density remote area's residents should be encouraged and supported to be self-sufficient. This includes off-grid water, electricity and sanitation as well as food production.	become an annual process, as part of the municipality's asset management plan. ✓ The Local municipality has the legislative mandate to make land use decisions as to where development may or may not take place. National, provincial and local municipal housing projects should be prioritized in existing settlement areas with bulk infrastructure. If and when development takes place in remote areas, the municipality should make provision for off-grid infrastructure services solutions.
Integrated Urban Development Framework 2016		
The IUDF, South Africa's national urban policy, takes as one of its key drivers the NDPs requirement that South Africa should see meaningful and measurable progress in the pursuit of more functionally integrated, balanced and vibrant settlements. The IUDF recognise that urban sprawl is an unsustainable development trend (increased services charges, land degradation etc.) and therefore proposes a growth model based on principles of compact and connected towns and cities. IUDF Priority: Controlling urban sprawl and fast track the implementation of SPLUMA through:	The IUDF adopted nine policy leaves, four of which are applicable to the study: Policy level 1: Integrated urban planning and management • More compact, socially inclusive and better-integrated cities that are resilient to climate change and urban risk; • Infrastructure investments that are sequenced, coordinated and integrated with land development; • Spatial integration to reverse undesirable settlement patterns emanating from past practices; and • Inclusive, safe, resilient and sustainable human settlements. Policy level 3: Integrated and sustainable human settlements	✓ Both Lephalale and Mogalakwena's should promote infill development and restrict urban sprawl through a strict urban development boundary to protect in tact natural landscapes. ✓ The municipalities water services development plan should align with the spatial proposals made by the SDF; ✓ The municipal land use scheme and SDF should limit the development of dispersing settlements in undesired location by allocating the desired land within existing well-located built-up areas. ✓ The location of settlements should be in harmony with nature e.g. not located in river buffers. ✓ Settlements experiencing a backlog in services should be identified for off-grid service solutions. See (5) See (4) See (1)

0. Enforcing the urban development boundaries/ Urban edge/ development lines 1. Locate all new investment within prioritised nodes or identified strategic areas, as per municipal plans. 2. Ensure that land use schemes encourage mixed land use development and higher densities 3. While making strong, guiding statements in the pursuit of shared, inclusive, resilient and liveable urban settlements, the IUDF cautions against a one-size-fits-all approach.	- Well-served, safe, cohesive and vibrant communities. Policy Level 4: Integrated urban infrastructure - Universal access to basic social and other services, which supports equality and inclusivity; - Environmental benefits, through the protection of ecological resources; and, Policy Level 8: Efficient land governance and management - Sustainable urban form (compact cities) and land use; - Resilient urban areas.	✓ Spatial planning and land use management on a local municipal level can contribute to urban resilience through green infrastructure solutions, creating compact urban forms.
National Water Resources Strategy (2013) & National Groundwater strategy (2016)		
The NWRS2 vision is to ensure “sustainable, equitable and secure water for a better life and environment for all”. It provides a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole and to identify water-related development opportunities and constraints. NWRS addresses sustainability, equity and efficiency through stating that water needs to be managed in an integrated way with relation to the hydrological cycle. Because all water resources are linked to each and are affected by the biophysical environment and human activities, water resources must be managed considering the relationships between water, the biophysical environment, and social, economic and political factors. This requires integrated management and the implementation of catchment management strategies in each water management area. The NGS goal is to ensure sustainable, accessible and cost-effective groundwater supplies for human survival and socio-economic development, while maintaining the environmental services that groundwater is supporting, in an	NWRS2 interventions: - Greater focus on WCWDM; - Increased value and utilisation of groundwater and re-use of wastewater; - Opportunity for more dams (though limited) and transfer schemes (and where the opportunity exists, it is at great cost); - Desalination: mine water desalination - Catchment rehabilitation - Clearing of invasive alien plants; - Rainwater harvesting; and - Sharply rise water costs Pollution of groundwater can be a serious problem because the impacts of activities on the land surface are poorly understood and contamination of the underground source can go undetected for a long time. NGS 2016 interventions - Groundwater sources for domestic use should receive the highest protection priority with measures such as: - Minimum requirements regarding borehole construction; - Wellhead protection zoning; - Site-specific protection of the aquifer (recharge zones) itself, where necessary. - Certain aquifers/areas need to be classified as no-go areas.	✓ UARL can be reduced by increasing settlement densities. ✓ SDF and land use schemes should limit and direct development away from areas where groundwater resources are at risk of being polluted. Increasingly, water reuse technologies should become part of building controls. The SDF should also identify and dedicate land to be used for the decentralised treatment of stormwater to be used elsewhere. ✓ Development should be avoided in areas where groundwater can be affected negatively by land use. ✓ Mining areas should have a designated site to treat mine water further use. this should form part of the mining application to be approved by the local municipality. Treated mine water should be distributed back to nearby settlements for non-potable use. ✓ The municipal SDF should identify areas where rehabilitation of the natural environment should take place – nearby communities should be identified for possible biodiversity stewardship programs to rehabilitate catchments. The municipal land use scheme should limit intensive development in catchment under stress and provide protective overlay zone in areas under threat. ✓ FEPA buffer zones should be delineated spatially in the SDF and in the Land Use Scheme and prioritised for rehabilitation strategies. ✓ Areas with a higher rainfall potential should be investigated for rainwater harvesting. The municipal land use scheme should also consider a clause that forces all new developments to implement rainwater harvesting tanks. ✓ The municipal billing system should be audited to identify non-paying customers. Reducing the volume of non-revenue water should get first priority. Increasing the cost of water will make

integrated development approach. Pollution of groundwater can be a serious problem because the impacts of activities on the land surface are poorly understood and contamination of the underground source can go undetected for a long time.		paying customers to use less, however, the change will not be seen in areas where customers are not paying at all.
National Protected Areas Expansion Strategy 2016		
The aim of this strategy is to achieve cost-effective protected area expansion for ecological sustainability and increased resilience to climate change through fiscal incentives for the consecration of biodiversity on private and communal land. The strategy refers to four main mechanisms including the acquisition of land, contract agreements, declaration of public land and Biodiversity Management Agreements.	The 2016 National Protected Areas Expansion Strategy sets a 20-year target to increase the countries protected areas network by 255 877 km² consisting of: • 104 962 km² marine benthic and coastal ecosystems; • 146 814 km² terrestrial ecosystems; • 2 352 km² wetlands; and • 1 490 km² rivers.	✓ The municipal SDF should give effect to the regional biodiversity plan and identify parcels of land with high ecological value (CBA & ESA) unaffected by development, in good ecological condition and located close to existing protected areas networks. The land use should further provide protective overlay zones to all FEPA zones.
National Biodiversity Strategy and Action Plan 2015-2025		
Conserve, manage and sustainably use biodiversity to ensure equitable benefits to the people of South Africa, now and in the future.	Target 2.1, by 2019; The network of protected areas and conservation areas includes a representative sample of ecosystems and species, and is coherent and effectively managed: • Echoes the targets of the NPAES 2016 • Target 2.2, by 2019 restore, maintain and secure important ecological infrastructure in a way that contributes to rural development, long-term job creation and livelihoods: • total of Hectares of land under restoration/restoration of 1 370 600 ha restored, with 3 230 271 ha of follow up treatment by DEA. • 695 wetlands should be rehabilitated • Target 3.2, by 2019 embed biodiversity considerations into national, provincial and municipal development planning and monitoring: • 100% of all SDFs being developed have biodiversity considerations.	✓ See the previous point ✓ The municipal SDF should identify areas where land uses and affected areas of environmental importance. Once again, the land use scheme should provide an overlay zone to affected areas to prevent further environmental degradation. ✓ Through spatial analysis, wetlands affected by land use can be identified and should be highlighted in the SDF as priority rehabilitation areas. Rehabilitation projects can be linked to biodiversity stewardship programs with nearby communities. ✓ SDF must align and adhere to all Bioregional, or

Source: Own Construction (2018) adopted form UN (2015); African Union Commission (2015); National Planning Commission (2011); The Presidency (2009), South Africa, (2018); COGTA (2016); DWS (2013); DWS (2016); DEA (2016) and DEA (2015).

Table 5-10 provides a summary of the case study analysis into Limpopo provincial policies and plans applicable to WSSP.

Table 5-10: Case study analysis into provincial policies applicable to WSSP

Key development directive	Relevance to the study	How does the plan affect local municipal land, water and environmental resource planning and management?
Limpopo Development Plan (LDP) 2015-2020		
The vision of LDP (2015-2020) is to fulfil the potential for the prosperity of Limpopo Province in a socially cohesive, sustainable, prosperous and peaceful manner. Critical provincial objectives include: • Improve the quality of life of citizens. • Promote vibrant and equitable sustainable rural communities. • Raise the effectiveness and efficiency of a developmental public service. • Ensure sustainable development.	The LDP focuses on transitioning to an environmentally sustainable, low-carbon economy. Sub-outcomes include • ecosystems are sustained, and natural resource is used efficiently; • an effective climate change mitigation and adaptation response is developed; • an environmentally sustainable, low carbon economy is created; • sustainable human communities are established.	✓ The SDF should delineate areas of environmental significance and direct development away for such areas. Alignment between the SDF and bioregional plans are critical. The LUS should provide restrictive development overlay zone in areas with ecological significance. ✓ As a preventative measure, the spatial location of human settlements should be directed away for areas with physical and underlying structuring elements. A variety of water sources should be tapped into in order to prevent one source of drying up. ✓ Green jobs such as clearing of alien invasive plants in FEPA should be priorities.
Limpopo Provincial Spatial Development Framework (2016)		
The Provincial SDF aims to create a provincial spatial structure where the natural environment and valuable agricultural land in the rural areas are protected for future generations, with a strong, diverse and growing economy focused around a range of nodal areas and that offers its residents high quality living environments and good job opportunities in a sustainable manner. The plan aims to promote social, economic and environmental sustainability throughout the Province and to ensure that it has relevance to the development needs of all the dispersed urban and rural communities in Limpopo Province which it represents.	Development Principle 1: Define and protect a Provincial Regional Open Space System which ensures that ecosystems are sustained, and natural resources are utilised efficiently. Development Principle 2: Facilitate efficient spatial targeting through the identification of a range of provincial, district, municipal and rural nodal points to serve as focal points for investment and service delivery. Development Principle 4: Direct engineering infrastructure investment towards the priority	Development Principle 1: This includes: • River courses and dams • All mountains and ridges • Declared conservation areas, nature reserves and conservancies • Critical biodiversity areas • Waterberg Biosphere Development Principle 2: The Provincial SDF categorised the following settlements in Lephalale Local Municipality accordingly:

The LSDF acknowledges every citizen's constitutional right to basic services. As far as possible, basic water and sanitation services should be incrementally rolled out to all towns and villages in the Province – irrespective of nodal status.	nodal points where the majority of economic activity and human settlement will establish. Development Principle 11: Sustainable Human Settlement in urban and rural Limpopo Province. Future 'urban' development (housing, economic infrastructure, community infrastructure, etc.) be consolidated around the identified nodes and that it be done to achieve the IUDF vision which reads as follow: "Liveable, safe, resource-efficient cities and towns that are socially integrated, economically inclusive and globally competitive, where residents actively participate in urban life".	• Provincial Growth Point: Ellisras/Onverwacht/ Marapong Node. • Municipal Growth Point: Thabo Mbeki • Rural Node Service Delivery Points: Setateng, Ga-Seleka The Provincial SDF categorised the following settlements in Mogalakwena Local Municipality accordingly: • Provincial Growth Point: Mokopane. • Municipal Growth Point: Bakenberg & Rebone • Rural Node Service Delivery Points: Marken/Rapadi Development Principle 4 & 11: If the bulk of future economic and residential development is consolidated around the proposed nodal network –then infrastructure investment in these nodes will serve a much larger population than what is currently possible. This will enhance the cost-benefit ratio to investments made in these areas.
Limpopo Water Management Area North Reconciliation Strategy 2016		
The Limpopo Water Management Area North Reconciliation Strategy provides reconciliation interventions for entire Limpopo WMA North up to 2040. The Reconciliation Strategy aims to address growing water demands as well as water quality problems experienced in the catchment and identifies resource development options.	Intervention options can be divided into main categories, namely: • intervention options that are water requirement focussed, with the aim to better manage water resources and to reduce water requirements; and • Intervention options that are resource focussed, with the aim to increase the yield available from existing water resources and the development of new water resources.	

Source: Limpopo Provincial Government (2015); Limpopo Provincial Government (2016) and DWS (2016b)

Table 5-11 provides a summary of the Waterberg District, Lephalale and Mogalakwena Local Municipality's policies and plans relevant to WSSP.

Table 5-11: Case study analysis into municipal policies and plans applicable to WSSP

Key development directive	How does the plan affect local municipal land, water and environmental resource planning and management?	
Waterberg District IDP 2017-18 Chapter (water/sanitation)		
To invest in a constituency of talented human capital who are motivated and innovative to build a sustainable economy in the field of energy, minerals and eco-tourism for the benefit of all our communities.	The environmental issues identified in the Waterberg District area includes sanitation; harvesting of firewood; water quality (Most of the rural communities rely on borehole s / bulk storage for water provision another challenge is the aged /old infrastructure which has a negative impact on the quality of water especially the chemical content) and air quality management.	✓ Most of the environmental issues listed in the Waterberg District IDP has a spatial component and is also affected by land use. These issues can and should be addressed by the spatial development framework while land use regulations for the protection of the broader district must be implemented on the local municipal level.
Waterberg Spatial Development Framework		
The Waterberg SDF is aligned with the Provincial Spatial Rationale and attempts to ensure alignment and integration between the six local municipalities in its area of jurisdiction.	The following proposals emanated from the District SDF is relevant to both study areas: • “The stimulation of priority nodes and corridors by means of focused investment in areas where settlement must be encouraged, and redevelopment initiatives that engender consolidation of settlement areas, while discouraging excessive investment in areas where settlement must be discouraged”. • “Undesirable/sensitive development should not occur in areas earmarked as environmentally sensitive, including within the Biosphere.”	✓ Local Municipal SDFs should align their spatial proposals and development initiative with the District SDF. Development should be guided by densification and growth management strategies, limiting the expansion of the built footprint onto the intact natural environment. ✓ Investment in fixed infrastructure should only take place in settlement represented by a promising economic sector. Redevelopment initiative should be informed by water sensitive development principle, thus also giving effect to the second point. ✓ Protective environmental zonings should be included and given effect to through the municipal land use scheme.
Waterberg District Bioregional Plan – 2016 / Waterberg District Environmental Management Framework Report		
The plan aims to inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity.	Conversion of extensive grazing farms to high-intensity breeding farms is having significant negative environmental impacts (overgrazing and loss of landscape connectivity). These activities are all associated with land-use change and associated loss or degradation of natural habitat, biodiversity and ecosystems. The pressures placed on the environment and the remaining natural ecosystems are accelerating with new economic developments unfolding in the Waterberg District. Further loss of natural habitat and ecological infrastructure is expected.	✓ Consequently, a bioregional plan for the Waterberg District is an appropriate tool for addressing the need to take biodiversity into account in land-use planning and decision-making, in order to promote sustainable development. However, the actual implementation of the plan must be regulated on local municipal level.

Lephalale IDP 2017-17		
Lephalale IDP states the municipalities vision “ A vibrant city and the energy hub” and mission “We are committed to rural development, provision of quality, sustainable and affordable services, financial viability and good governance, local economic development and job creation.” The IDP provides a comprehensive status quo analysis of the municipality and sets the budgets for all future projects.	Lephalale IDP reported on priority issues linked to strategic objective to guide budget inputs. Strategic objective relevant to this study includes: • Provide quality and well-maintained infrastructural services in all Municipal areas • Protect the environment and improve community well-being	✓ In terms of the first strategic objective, Lephalale Local Municipality’s needs to refurbish its existing infrastructure that is ageing due to increasing population size as the economy grows. It should adopt an Infrastructure Investment Master Plan which is informed by the Municipal Spatial Development Framework. This plan should assist the municipality to classify the current state of infrastructure, assist with integrated planning to ensure planning for provision and refurbishment of infrastructure is taken into consideration and carefully planned. Water sensitivity should be the main objective of this plan. ✓ In terms of the second strategic objective, the municipality should come up with innovative ways on how it can increase community awareness and participation in environmental management (pollution, waste and emissions) activities and initiatives. The IDP also calls for the development of an environmental management plan which ought to give rise to intensifying recycling initiatives.
Mogalakwena IDP 2017-18		
Mogalakwena’s IDP states the municipalities vision “To be the leading, sustainable and diversified economic hub focused on community needs” and mission “providing affordable and quality basic services; creating a conducive and sustainable environment for social and economic development; and being consultative, responsive and accountable. The IDP provides a comprehensive status quo analysis of the municipality and sets the budgets for all future projects.	Mogalakwena’s IDP lists several strategic objectives including: • Foster, regulate, maintain and promote a sustainable environment • / Improved quality of life and protect natural resources for future generations; • to improve the quantity and quality of municipal infrastructure and services / Enhanced and sustainable socio-economic growth.	✓ The municipal SDF must guide development away from any environmentally sensitive areas while the municipal land use scheme is an effective tool to provide legal protection overall protected areas and natural environments in need of legal protection. ✓ Improving the quality and quality of municipal infrastructure services should not only look at conventional infrastructure solutions but also alternatives such as rainwater harvesting, greywater reuse, SuDS etc.

Source: Waterberg District Municipality (2017); Waterberg District Municipality (2009); Waterberg District Municipality (2016); Lephalale Local Municipality (2018); Mogalakwena Local Municipality (2017).

5.4.1.3 Empirical Investigation Phase 2.1: Key findings and conclusion

The previous chapters established that spatial planning and land use management decisions and activities have both a qualitative and quantitative impact on water resources. Municipal planning tools should, therefore, give effect to water and environmental-related legislation, policies and plans to secure future water resources. The primary goal of the Water Sensitive Legislative and Policy Analysis was to determine the degree to which a typical local municipality, in this case, Lephalale Local Municipality and Mogalakwena Local Municipality, can and should give effect to land, water and environmental reform through WWSP.

Based on the preceding review of all national legislation, policies and plans, engaged with land, water or environmental resources planning and management, it is evident that local municipalities have more than enough high-level guidance on how to achieve sustainable land, water and environmental reform. However, the review of all provincial, district and local municipal legislation, policies and plans, engaged with land, water or environmental resources planning and management proved that local level implementation is not sufficient.

It is uncommon for municipal planning documents to have a “target analysis” included as part of their policy reviews. However, Section 5.4.1.2 identified several national targets which impose either land, water or environmental resource related implication. These targets were used to guide and inform the various evidence based spatial analysis methodologies. For example, the Water Sensitive Biophysical Analysis aims to identify a percentage of land within the municipality’s border, eligible to form part of the National Protected Areas Expansion Strategy which has a set target of adding 2.7 million hectares to the land-based protected area network. Furthermore, the Water Sensitive Built environment analysis will aim to prove that urban water demand can be reduced by 15% below business as usual.

Based on the information provided in Phase 2.1 of the empirical investigation, Phase 2.2 of the empirical investigation aims to give effect to the development directives and objections as summarised in the preceding tables.

5.4.2 Empirical Investigation Phase 2.2: Water Sensitive Spatial Analysis - design and details

Phase 2.2 of the empirical investigation applied a quantitative research method based on the systematic analysis of spatial dimensions (population patterns, land use and water) through GIS software, GIS data and other numeric data source (Le Gates, 2005). Thus, the researcher used ArcGIS, sourced various national spatial dataset, identified alternative numeric datasets including municipal billing information and census data, which was used throughout the process of conducting a Water Sensitive Spatial Analysis.

GIS systems and tools: The researcher gained access to ArcGIS Desktop 10.6.1 (July 2018) were ArcMap, ArcCatalog, and ArcScene was used to create maps, perform spatial analysis, and manage geographic data, ultimately to derive and evidence based results.

Spatial and numeric data: The process of conducting a meaningful Water Sensitive Spatial Analysis depends on the availability and accuracy of spatial data. Institutions such as Agricultural Research Council (ARC), South African National Biodiversity Institute (SANBI) and the Biodiversity Geographic Information System (BGIS) has played a fundamental role in developing national spatial datasets to identify and address issue and opportunities related to climate, geology, terrain, soils, vegetation, protected and conservation areas, critical biodiversity areas and ecological support areas. Up until recently, spatial information dealing with water resources quality and quantity has been severely limited. As a result, previous spatial hydrological investigations were mostly limited to a map, indicating the spatial location of rivers, dams and wetlands without considering the resources quality and quantity. A review of previous planning documents also indicated that groundwater resources have been ignored entirely. The reason could be due to a lack of spatial data or purely because it is an underground source not visible to the naked eye. Fortunately, new spatial information, related to water resource quality and quantity has recently been made available for public use. Unfortunately, national datasets have low-resolution as its usually mapped at a scale of 1:250 000 or greater. This is a limiting factor when assessing spatial concerns at municipal level and even more so when dealing with individual sites. Annexure E list the datasets or shapefiles that were used throughout for the Water Sensitive Spatial Analysis.

Other numerical data, including municipal billing data and census data was joined to a spatial entity through GIS-Spatial Analyst. These datasets were obtained from Lephalale and Mogalakwena's Municipal Officials as listed in Table 5-12.

Table 5-12: Municipal officials

Stakeholders	Position	Contact details
Ms C. Mutshavi	Town and Regional Planner: Lephalale Local Municipality	Catchlife.Mutshavi@lephalale.gov.za
Mr S. Ntshani	Chief Town and Regional Planner: Mogalakwena Local Municipality	Solani Ntshani (ntshanis@mogalakwena.gov.za)

Source: Own Construction (2018)

As illustrated in Section 5.2, Phase 2.2 of the empirical investigation consist three main themes of investigation, informed by several detailed thematic investigations, each of which has its own unique methodology. The three main themes include:

- i) Water Sensitive Biophysical Analysis - Section 5.4.2.1, elaborates on methodology and technical aspects adopted by this study in order to conduct the Water Sensitive Biophysical Analysis. The objective of this analysis was to identify areas of ecological importance, specifically in freshwater ecosystem priority areas to be protected from land use change to create cities/settlements that provide ecosystem services. The aims of this quantitative systematic analysis were to determine the hydrological and geological characteristics of the municipality; identify areas of ecological significance; determine the spatial location and percentage of natural landscapes that have been affected by development; identify priority intervention zones; and identify areas where groundwater can be utilised as a resource. The systematic analysis of spatial data throughout the Water Sensitive Biophysical Analysis resulted in a thematic distribution findings, to be presented in the following section:
 - **Theme 1:** Physical and Underlining Structuring Elements (unique methodology Table 5-13);
 - **Theme 2:** Macroscale Water Quality and Quantity Assessment (unique methodology Table 5-14); and,
 - **Theme 3:** Protected Areas and Areas with Management Requirements (unique methodology Table 5-15).
- ii) Water Sensitive Built Environmental Analysis - Section 5.4.2.2, elaborates on methodology and technical aspects adopted by this study in order to conduct the Water Sensitive Built Environment Analysis. The objective of this analysis was to determine the qualitative and quantitative impact of urban land use on water resources and identify opportunities to create cities/settlements as water catchments and provide ecosystem

services. The aims of this systematic spatial analysis was to determine the land use water quantity impact by linking land use and water billing information; determine the rainwater harvesting potential with the municipality's urban areas; evaluating the level of threat posed by land use and land use activities on stormwater runoff by joining a generic threats table to the existing land use data; determine the possible spatial location of a Blue-green corridor development zone; and, determine the existing development density and the availability of vacant land in order to promote higher density development to reduce the UARL within a water distribution network and to protect natural landscapes unnecessary destruction. The systematic analysis of spatial and numerical data throughout the Water Sensitive Built Environment Analysis resulted in a thematic distribution findings, to be presented in the following section:

- **Theme 1:** Land Use Water Quantity Impact (unique methodology Table 5-16);
- **Theme 2:** Land Use Water Quality Impact (unique methodology Table 5-28); and,
- **Theme 3:** Settlement Form: Densification (unique methodology Table 5-31).

iii) Water Sensitive Socio-Economic Analysis –Section 5.4.2.3, elaborates on methodology and technical aspects adopted by this study in order to conduct the Water Sensitive Socio-Economic Analysis. The objective of this analysis was to determine the current and future socio-economic demand for water and identify opportunities to change cities/settlements into water sensitive communities. The aims of this systematic spatial analysis were to determine the determine household access to services (Potable water and sanitation services); determine household income and affordability levels; and, determine future household water needs. The systematic analysis of spatial and statistical data throughout the Water Sensitive Socio-Economic analysis resulted in a thematic distribution findings, to be presented in the following section:

- **Theme 1:** Services Assessment: Potable Water and Sanitation (unique methodology Table 5-33); and,
- **Theme 2:** Future Needs (unique methodology Section 5.4.2.3.2).

After each analysis, the findings for Lephalale Local Municipality will be presented, followed by the findings for Mogalakwena Local Municipality. A conclusion is drawn after every analysis.

Section 5.4.2.1, Section 5.4.2.2 and Section 5.4.2.3 to follow reveals the findings of the empirical investigation phase 2.2: Water Sensitive Spatial Analysis.

5.4.2.1 Water Sensitive Biophysical Analysis

The Water Sensitive Biophysical Analysis provides insights on the broader environmental characteristics of a municipality and the state of its natural resources base on which life depends. The analysis identifies and access all biophysical structuring elements also referred to as Ecological infrastructure (EI) which is the nature-based equivalent of engineered infrastructure. Identifying wetlands, river, dams, estuaries and areas with high groundwater resources for future protection and if needed rehabilitation is the key focus of the analysis.

The Water Sensitive Biophysical Analysis has a vital role to play in addressing the pillars of practice, specifically, cities/settlements providing ecosystem services.

5.4.2.1.1 Physical and underlining structuring elements

Physical structuring elements such as hills, rivers and wetlands provide ecological services and development direction within a municipality. Although engineering solutions have evolved to overcome certain physical constraint, altering physical structuring elements is considered bad practice and should be avoided as far as possible. While physical structuring elements are generally visible to the naked eye, underlining structuring elements are not, and are therefore generally excluded form SDFs and LUSs - as noted throughout the preceding literature review. The geology of a region determines both the quality and quantity of groundwater resources as rock types have different physical (permeability) and chemical compositions. Underlining structuring elements can also hinder development and vice versa. One of the pillars of practice of achieving water sensitive cities/settlements, is for cities/settlements to provide ecosystem services. One way of achieving this is to direct spatial growth away from ecological infrastructure.

Based on the information gathered throughout the literature review, Table 5-13 describes the evidence based methodology used to identify the spatial location of physical and underlining structuring elements and the extent to which anthropological land uses have affected the above-mentioned elements.

Table 5-13: Physical and underlining structuring elements methodology

Map	Determine the spatial location and extent of... Method / Steps
Physical structing elements	
All basemap data - A01 ; A02; A03; A04; A05; A06; A07; A08; A09; A10; A11; A12; A13; and A14 Infrastructure data - A20; A21; A22; A23; A24; A25; A26; A27; and A28 Slope and contours - A29	... high and almost undevelopable high slopes with a slope gradient of over 25%. - Convert the Slope rasterfile (A29) to a shapefile using the “Raster to feature” in tool GIS. - Use the “Select by attribute” function in GIS to extract all spatial areas affected by a slope gradient of over 25%. - Once selected, export the polygons as a new shapefile and label it “Undevelopable High Slopes.shp”.
Add to the above Primary and secondary rivers - A31 - A32 Wetlands and estuaries - A33 Impoundments - A34	... primary and secondary rivers, wetlands, estuaries and impoundments. Use the “Geoprocessing” – “Buffer” tool in GIS to create a 100m buffer around the primary river network and a 50m buffer around the secondary river network. The 100m and 50 m buffer is now considered to be the new spatial extent of rivers. Impoundments can be left as is.
Underling structing elements	
Add to the above Geology A47	...dolomitic areas - Repeat step 2 but extract all spatial data representing areas with “Dolomitic” characteristic. - Once selected, repeat step 3 and label the new shapefile as “Dolomitic areas.shp”.
Add to the above Soil drainage A49	...impeded soil drainage - Repeat step 2 but extract all spatial data representing areas with “high swelling clay” potential. - Once selected, repeat step 3 and label the new shapefile as “Impeded soil drainage.shp”.
Add to the above Swelling clays A48	...areas with high swelling clay potential. - Repeat step 2 but extract all spatial data representing areas with “impeded soil drainage” characteristic. - Once selected, repeat step 3 and label the new shapefile as “High swelling clay.shp.”
Add to the above Groundwater recharge potential A42	...areas with moderate to high mean recharge potential (mm/a). - Use the “Symbology” – “Quantities” – “Gradated Colour” tool to display the “<i>Recharge</i>” by “Equal Interval (4 Classes)” to differentiate between four classes of groundwater recharge potential (e.g. very low; low; moderate and high) - Extract the data representing aquifers with naturally high permeability and create two new shapefiles: “Moderate to high GWRP.shp” “High GWRP.shp”.
Final Map	

Map the following physical structuring elements • Undevelopable high slope; • Primary Rivers (100m Buffer); • Secondary Rivers (50m buffer); • Wetlands and estuaries; and • Impoundments Underlining structuring elements • Dolomitic areas; • Impeded soil drainage; • Moderate to high GWRP; and • High GWRP.	...all physical and underlining structuring elements 13. Add the land use data as captured in the land audit process. • Urban land use • Village land use • Agricultural land use • Mining land use 14. For reporting purposes, use the “select by location” tool in GIS to select all “urban land use”; “village land use”, “Agriculture” and “Mining” as “Target Layers” and select each of the physical and underlining structuring shapefiles as “Source Layer” to identify where land use, physical and underlining structuring elements are in conflict. 15. Once land use conflict has been identified, use the use the “Calculate Geometry” function to determine the physical extent (km²) of the affected areas.

Source: Own construction (2018) see Annexure E for data source list.

Section 5.4.2.1.1.1 and Section 5.4.2.1.1.2 to follow, summarises and spatialise the key findings of the physical and underlining structuring elements analysis for Lephalale and Mogalakwena Local Municipality. Section 5.4.2.1.1.3 reflects on the key findings and draws a conclusion.

5.4.2.1.1.1 Lephalale physical and underlying structuring elements

The DWS provides national scale spatial data on South Africa's primary and secondary river networks, wetlands, estuaries and impoundments. Using the evidence based methodology provided in Table 5-13 the spatial analysis revealed that 0.6 km² of agricultural; 0.2 km² of formal urban; and, 0.4 km² of informal village land uses are currently located within the 100m primary river buffer. Fortunately, the 50m buffer zone assigned to the municipality's secondary river network is free of any land use conflicts. The spatial data also indicates that Lephalale Local Municipality has approximately 17 000 wetlands covering a surface area equivalent to 95 km². Approximately 110 wetlands equivalent to 42 km² has been affected by either agriculture, mining, urban or village land uses. The latter two is accountable for the loss of 13 wetlands with a total coverage of 17 km².

In terms of underlining structuring elements, swelling clays are known to take water in readily when dry but exhibit high runoff when wet and expanded. These expansive soils can damage foundations and walls of buildings by “uplifting” as the moisture content increase. Thus, soils with swelling clay potential are underlining structuring element to be avoided by development at all times.

According to the spatial data, 153 km² of the municipality's sub-surface area has high swelling clay potential, the majority of which is found in A50G within the region of Abbottspoort. The land use data further indicate that this area of land is predominantly used for cultivated commercial fields, pivots, and orchards and some plantation. Soil texture and organic matter are key components that determine soil water holding capacity. Soils with poor or impeded drainage commonly support wetlands, yet they can also easily flood in during high rainfall events. According to the spatial data, A sum total of 15.7 km² of agricultural; 1.7 km² of mining; and 5.9 km² of urban land uses are located on areas with impeded soil drainage and can be affected by flooding if heavy storms occur. Furthermore, 0.5 km² of the identified urban land use, is currently being used for public open space, could potentially be utilised for constructed wetlands within the built-up urban area.

Throughout the literature review, groundwater was highlighted as a resource “unknown” to Urban and Regional Planners. As a result, spatial planning and land use management documented barely ever include groundwater resources in spatial assessments or proposals. Groundwater Recharge Potential (GWRP) is determined by its geological permeability. The issue of whether water can get into the aquifer rapidly enough depends on the permeability of the aquifer.

According to the spatial data, the GWRP is relatively low throughout the northern region ranging between 0 mm/a – 99 mm/a; increasing towards the south where it ranges between 100 mm/a – 300 mm/a. Figure 5-9 illustrates GWRP ranging between 108 mm – 141 mm to be moderate covering a spatial area of 2 560 km² thought quaternary catchment A42G where Afguns and Elemston are located; A42F where Witfontein, Hermanusdooring, Hartebeesdrift and Bulge Rivier is located and A41B; A41A and A50D. High GWRP ranging between 142 mm - 178 mm covering 91 km² of sub-surface areas is found in quaternary catchment A42D.

According to the evidence based spatial assessment, 87.6 km² of agricultural, 0.2 km² mining; 3.2 km² of urban land uses are located within areas with moderate to high GWRP. Land use activities found in areas with moderate to high GWRP can cause groundwater contamination and should be managed very carefully.

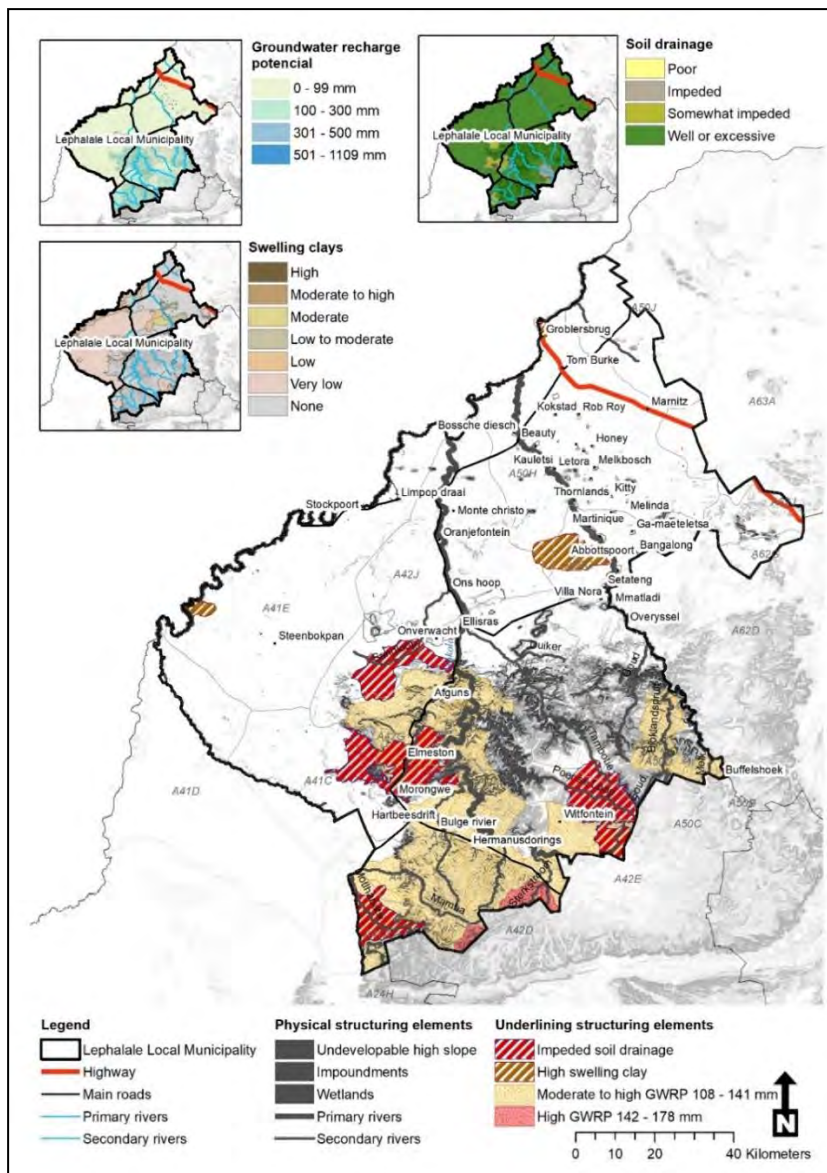


Figure 5-9: Lephalele's physical and underlining structuring elements

Source: Own construction (2018)

Lephalele Local Municipality existing SDF address the concerns of undevelopable high slopes (Lephalele Local Municipality, 2017a:37) and it provides some information on the municipalities hydrological network (rivers specifically) (Ibid.:46). Unfortunately, it does not make any reference to wetlands or impoundments nor does it examine the impact of existing land use on wetlands. In terms of underlining structuring elements, the existing SDF provides a thorough assessment of the municipality's geology, terrain types, soil classes, swelling clays and soil drainage (Ibid.:36-41). However, the spatial implications of these underlining structuring elements are limited to buildings in general and not on any environmental implication. Furthermore, groundwater and the impact of development on groundwater resource has been ignored entirely.

5.4.2.1.1.2 Mogalakwena physical structuring elements

As mentioned in Section 5.3.1.2, Mogalakwena Local Municipality also falls within the Limpopo Water Management Area, Primary Catchment A with A5 and A6 as secondary catchments. Mogalakwena Local Municipality has two perennial rivers including the Lephalala river, and the Mogalakwena flowing south to north nearly bisecting the municipal area which is defined by the Waterberg in the west and the Strydpoort mountains in the south-east. According to the evidence based analysis, the spatial data revealed that 47.5 km² of agricultural and 3.70 km² of village land uses are located within the 100m primary river buffer. Furthermore, the spatial data revealed that the 50m buffer zone assigned to the municipality's secondary river network is affected by 35.5 km² of agricultural; to 2.4 km² of mining; 1.9 km² of urban and 16.5 km² of informal village land uses. Clearly, informal village land uses is a major threat to the municipality's existing rivers network. In terms of wetlands, the spatial data indicates that Mogalakwena Local Municipality has approximately 1 020 wetlands covering a surface area equivalent to 146.2 km². Approximately 137 wetlands equivalent to 49.4 km² has been affected by either agriculture, mining, urban or village land uses. The latter two, are accountable for the loss of 13 and 26 wetlands respectively with a total coverage of 12.2 km².

In terms of underlining structuring elements, large segments of underlining swelling clay potential covering 362.9 km² are found throughout the Mogalakwena Local Municipality. Figure 5-10 shows that Ga-Mathekga; Ga-Molekwa; Ga-Mabusela; Ga-Modipana; Gamapela; Lenkwene; Ga-Mmalepeteke; Magagamatala; Malokong and Mmahlogo is affected by areas with high swelling clay potential.

As mentioned previously, these clay soils are highly susceptible to change when in contact with water resource. Mogalakwena's soil water holding capacity is only somewhat impeded and covers a subsurface area of 85 km² towards the northwestern region. 26 Wetlands, equivalent to 6.4 km² is supported by areas with somewhat impeded soil drainage potential. According to the spatial data, agricultural land use is the predominant land use found within this area.

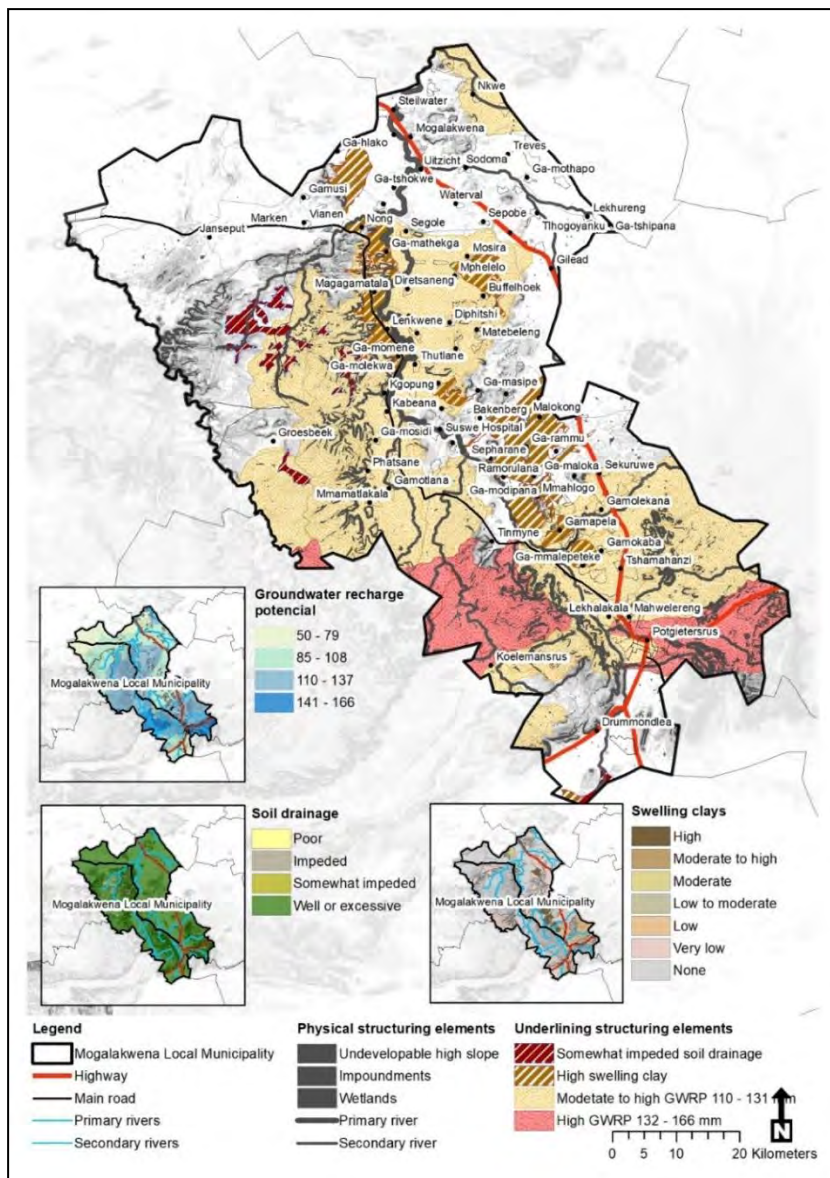


Figure 5-10: Mogalakwena's physical and underlining structuring elements

Source: Own Construction (2018)

Unlike Lephalale Local Municipality, Mogalakwena's GWRP is relatively high throughout ranging between 100 mm/a – 300 mm/a. Figure 5-10 illustrates GWRP ranging between 110 mm – 131 mm to be moderate covering a spatial area of 2 519 km² throughout quaternary catchment A62H; A62C; A62D; A26B; A50B; A62A; A61J and A61G. High GWRP ranging between 132 mm-166 mm covering 535 km² of sub-surface areas is found in quaternary catchment A61J and A61F. Moderate to high GWRP is so vast throughout the municipality, that almost all urban and rural settlements are located in areas with moderate to high GWRP. The land use groundwater quality impact should be monitored carefully as groundwater contamination is not easily treated.

Mogalakwena's existing SDF address the concerns of slope and drainage and highlights the direct link between the two elements and municipal sanitation and stormwater services (Mogalakwena Local Municipality, 2009). The existing SDF also highlights the concern of limited water resource availability and provides some information on the municipalities hydrological network, specifically rivers and impoundments (Ibid.). However, wetland water bodies were once again ignored entirely.

In terms of underlining structuring elements, Mogalakwena's SDF provides a thorough assessment of municipality's geology, terrain types, soil classes, swelling clays and soil drainage (Ibid.). However, the spatial implications of these underlining structuring elements are limited to buildings in general and not on the environmental implication. Furthermore, groundwater and the impact of development on groundwater resource have been ignored entirely.

5.4.2.1.1.3 Physical and underlining structuring elements: Key findings and conclusion

The evidence based physical and underlining structuring elements analysis shows that both municipalities have certain areas where development is constrained by undevelopable high slope, rivers, wetlands and impoundment. In terms of development, steep slopes make the provision of infrastructure more difficult and expensive. Regarding water resource, steep slopes also change flow patterns in rivers and wetlands (frequency, amplitude, direction and flow) as it encourages surface runoff in response to rainfall events. The result of which is higher surface runoff with a natural tendency for creating "flashy" flow properties in rivers (Macfarlane, *et al.*, 2014:135). Wetland systems located at the base of steep catchments with poor infiltration rates are also sensitive to heavy rainfall events and are therefore more likely to be characterised by natural flashy floods (Ibid.:116).

In both case study areas, rivers, wetlands and impoundments have been affected by anthropogenic land uses. One of the causes could be due to the fact that many rivers and wetlands may have dried up over time. Due to the unregulated allocation of land in many village settlements, the spatial location of dried-up water bodies will often be ignored.

Rivers, wetlands, estuaries and impoundments are essential ecological infrastructure and should, as far as possible be protected from physical development. In both municipalities, the spatial location of areas affected anthropological land use has been identified. These areas should be priorities for further investigation to identify the extent of physical impact on water resources. Households located in flood lines, especially in areas located at the bottom of steep slopes should be prioritised for reallocation of stands.

Furthermore, these areas should be prioritised for rehabilitation and revegetation, especially wetlands and river buffers located at the bottom of high slopes. In terms of SuDS selection, Section 4.3.1.2 highlighted that filtered strips are commonly used along stream banks as vegetated buffer systems and also downstream from agricultural land to intercept and infiltrate stormwater runoff.

Swelling clays are relatively limited in Lephalale, however, the majority of Mogalakwena's informal settlements are affected by swelling clays. As noted in the assessment, clay soils take water in readily when dry but exhibit high runoff when wet and expanded. In terms of development, these expansive soils can damage foundations or walls of buildings by "uplifting" as the moisture content increases. This will typically occur only in relative wet seasons.

Impeded soil drainage, also referred to as the soil's water holding capacity is determined by soil textures and organic matter. Several areas in Lephalale has been identified to have impeded soil drainage, while Mogalakwena Local Municipality has limited areas affected. Areas with impeded soil drainage are known to support wetlands. As such, areas with impeded soil drainage can lend itself towards the development of constructed wetlands to treat stormwater runoff or effluent from nearby settlements, such as Elemson in Lephalale Local Municipality. However, Section 4.3.1.3 noted that the use of constructed wetlands to treat wastewater can take up to 2 years to reach maximum treatment efficiency.

Groundwater in South Africa is widely recognised as an under-utilised resource. In both case study areas, high levels of GWRP exists. These areas are relatively limited in Lephalale Local Municipality whereas, almost the entire mid region of Mogalakwena Local Municipality has high GWRP. In both municipalities, anthropological land uses cover large areas with moderate to high GWRP. These land uses can cause groundwater contamination as the infiltration potential of surface water runoff is high, carrying pollutants into the aquifer. On the other hand, if groundwater levels have dropped in an aquifer with high permeability due to overutilization, aquifers can be recharged through artificial borehole injection, also referred to a Managed Aquifer Recharge (see Section 4.3.2). This practice is also recommended in areas affected by high evaporation rates. A perennial source of municipal water is treated wastewater. Increasingly wastewater is being recycled in some form or another – usually for irrigation, of golf courses, municipal gardens etc. If the intended use is for domestic supply, then water needs to be treated to compliance standards and recharged in a sandy aquifer where the travel time to the borehole is sufficient to allow for acceptable die-out of harmful micro-organisms.

The land use scheme should implement a management overlay zone (e.g. Potential Groundwater Development Zone) that regulates the intensity of land use in areas with moderate to high and very high GWRP. This management overlay zone should set Development Controls to increase permeability, which can be achieved through permeable paving or soakaways (see Section 4.3.1.1). See further recommendations on how this analysis can inform municipal planning tools to achieve WSS as provided in Chapter 7.

5.4.2.1.2 Macroscale water quality and quantity assessment

Water quality and quantity concerns are hardly ever addressed in spatial planning and land use management documents. Reasons could be due to a lack of spatial data representing this type of information or the lack of knowledge on how to interpret water quality and quantity data. The purpose of this analysis is to determine the land use water quality impact measured in terms of the level of surface water sediment pollution, the volume of Total Dissolved Solids, and the electrical conductivity (EC) levels in groundwater.

Surface water from dams and rivers are the main source of water for domestic and economic purposes. Unfortunately, overutilization, land use change and pollution have led to a decline in water resource availability. The analysis therefore also aims to identify a relationship between land use and water resource quantity impact. The DWS provides information on the Cumulative Neutralised Streamflow (no land use included) at key point (million m³/a) and Cumulative Present-Day Streamflow (with land uses as at 2009/2010) at key points (million m³/a). While new information on groundwater availability or the Utilisable Groundwater Exploration Potential (UGEP) has recently been published by the DWS. Table 5-14 describes the evidence based methodology used to conduct a macro scale water quality and quantity assessment.

Table 5-14: Macroscale water quality and quantity assessment methodology

Map	Determine the spatial location and extent of... Method / Steps
Water quality	
All basemap data - A01 ; A02; A03; A04; A05; A06; A07; A08; A09; A10; A11; A12; A13; and A14 Infrastructure data - A20; A21; A22; A23; A24; A25; A26; A27; and A28 Physical Structuring elements - Undevelopable high slope; - Primary Rivers (100m Buffer);	...catchments with high levels of sediment yield (1 000 t/a) and determine the TDS in various catchments. 1. Use the “Add field” tool in GIS to add a new field to A63 attribute table and label the field “SW quality concern” 2. Use the “Symbolology” – “Quantities” – “Gradated Colour” tool to display the “yield_1000” by “Equal Interval (4 Classes)” to differentiate between four classes of sediment yield: • Low sediment yield • Moderate sediment yield • High sediment yield • Very high sediment yield

- Secondary Rivers (50m buffer); - Wetlands and estuaries; and - Impoundments Sediment yield 1 000 t/a - A63 Total Dissolvent Solids (TDS) - A64	3. Identify areas affected by high and very high sediment yield areas and export the data as a new shapefile (e.g. - High sediment yield - 89 000 t/a - Very high sediment yield - 95 000 t/a 4. Total Dissolvent Solids (TDS) should be mapped as is.
Add to the above Groundwater Electrical Conductivity (EC) A43	... groundwater quality within the municipality. 5. Repeat step 1 but label the field "GW quality concern" 6. Repeat step 2 and select the "Groundwater" and method "Equal Interval (4 Classes)" to differentiate between - Good GW quality 0-70 mS/m - GW quality concern 70-300 mS/m - High GW quality concern > 300 mS/m 7. Use the "Field calculator" to update the "GW quality concern" attribute accordingly.
Water quantity	
Add to the above Cumulative Neutralised Streamflow A65	...catchments where the present-day-streamflow is less half than that of the neutralised streamflow. 8. The data is displayed as a graphic but has clear spatial reference.
Add to the above Utilisable Groundwater Exploration Potential (UGEP) A41	...catchments where the UGEP is very low and very high. 9. Use the "Raster to Polygon" tool in GIS to convert the UGEP raster dataset to a shapefile with differentiated features. 10. Use the "Symbology" – "Quantities" – "Gradated Colour" tool to display the "UGEP" by "Equal Interval (4 Classes)" to differentiate between four classes of evaporation (e.g.): - Very low UGEP < 2 500 m³/km²/a - Very high UGEP > 25 000 m³/km²/a 11. Create two new shapefiles "Very Low UGEP.shp" "Very High UGEP.shp"
Final Map	
Map the following Macro scale water quality data - High sediment yield - Very high sediment yield - Total Dissolvent Solids - Good GW quality - GW quality concern - High GW quality concern Macro scale water quantity data - Cumulative Neutralised Streamflow - Very low UGEP - Very high UGEP	...areas the good and bad surface and groundwater quality ...all areas with high and low availability of groundwater resource 12. Add the land use data as captured in the land audit process. - Urban land use - Village land use - Agricultural land use - Mining land use 13. For reporting purposes, use the "select by location" tool in GIS to select all "urban land use"; "village land use", "Agriculture" and "Mining" as "Target Layers" and select each of the macro scale water quality and quantity shapefiles as "Source Layer" to identify where land use, water quality and quantity conflict areas. 14. One land use conflict has been identified, use the use the "Calculate Geometry" function to determine the physical extent (km²) of the affected areas.

Source: Own construction (2018) see Annexure E for data source list.

Section 5.4.2.1.2.1 and Section 5.4.2.1.2.2 to follow summarises and spatialise the key findings of the macroscale water quantity and quality assessment for Lephalale and Mogalakwena Local Municipality. Section 5.4.2.1.2.3 reflects on the key findings and draws a conclusion.

5.4.2.1.2.1 Lephalale macro scale water quantity and quality assessment

Land use and land use change are known to cause sediment pollution as the disturbance of natural landscapes causes loose sand, clay, silt and other soil particles to settle at the bottom of waterbodies. The DWS provides national scale spatial data on Sediment yield 1 000 t/a which quantifies the amount of quaternary sub-catchment sediment yield (1000 t/a). Figure 5-11 illustrates that quaternary catchment A42J and A50H and A41E situated in the north has sediment yields of over 89 000 t/a and 95 000 t/a respectively. These catchments are also most populated by informal rural settlements, most likely the source of sediment pollution. Land use and land use change also contributes to increased levels of Total Dissolved Solids (TDS) in waterbodies which represents the amount of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some small amounts of organic matter. The main cause of TDS in drinking water originates from natural sources, sewage, urban run-off, industrial wastewater, and chemicals used in the water treatment process, and the nature of the piping or hardware used to convey the water. In terms of the catchment's TDS, the spatial data indicates that the TDS is relatively low ranging between 0-500 mg/l.

Groundwater pollution is a major problem in South Africa as the impact of land activities on groundwater resources are poorly understood and contamination of groundwater sources can go undetected for a long time. Groundwater quality is determined as the amount of salinity found in water, measured as electrical conductivity (EC) expressed in units of mS/m. The target water quality is between 0 and 70 mS/m while EC above 150 mS/m water will have a marked salty taste. Figure 5-11 illustrates the Electric Conductivity (EC) of groundwater within Lephalale Local Municipality. According to the spatial data, 1 580 km² of subsurface areas has groundwater which is of good quality as the EC is below 70 mS/m. This is mostly found towards the south and western regions of the municipality. The spatial data also indicates that 418 km² is of poor or bad groundwater quality. Settlements including Gaseleka, Kauletsi, Lebu, Letlora and Tshelamake were found to be located within regions which has high EC > 300 mS/m in groundwater. Boreholes located within this region should be tested regulatory. As for the remaining aquifers, EC ranges between 70 – 300 mS/m which is not ideal.

Regarding water quantity, in Lephalale Local Municipality and more specifically the Moloko dam, the cumulative neutralised streamflow is calculated at 241 000 000 m³/a whereas the present-day streamflow is calculated 156 000 000 m³/a. This indicates that when land use is added, the cumulative neutralised streamflow (availability) reduce by almost half.

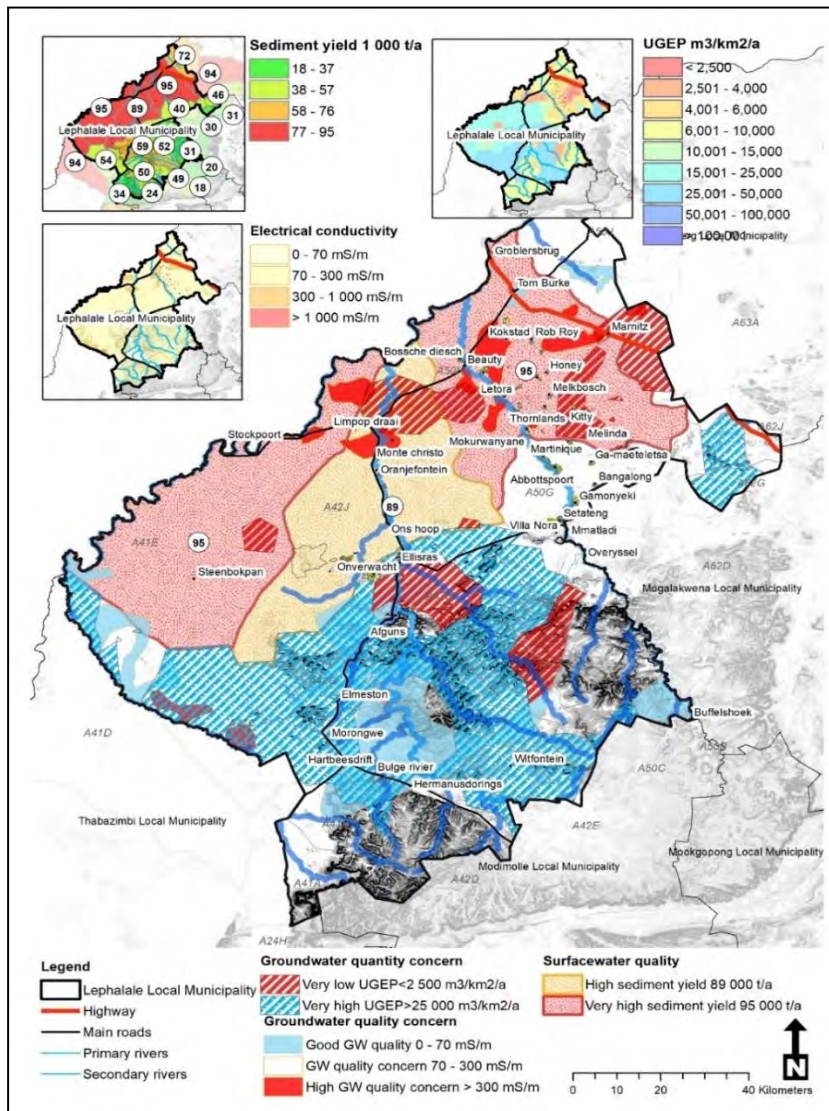


Figure 5-11: Lephalale's macro scale water quality and quantity analysis

Source: Own construction (2018)

In terms of groundwater availability, the total volume of available, renewable groundwater is described as the UGEP allowing for factors such as physical constraints on extraction, portability, and a maximum allowable drawdown. Figure 5-11 illustrates that UGEP is highly irregular throughout Lephalale Local Municipality. UGEP is lowest in the North where most informal rural settlements are located.

It increases towards the south and western region where it ranges between 15 000 m³/km²/a and 50 000 m³/km²/a. Ellisras, Onverwacht; Afguns, Elveston. Morongwe, Hartebeesdrift; Blurge Rivier, Hermanusdooring and Withfontein are located within high UGEP areas.

Lephalale Local Municipality existing SDF does not provide any information regarding the quantity or quality of surface water or groundwater resource nor does it make any reference to the possible impact of land use on water resources.

5.4.2.1.2.2 Mogalakwena macro scale water quality and quantity assessment

In Mogalakwena, the Sediment yield 1 000 t/a is relatively low throughout the north and western regions, increasing to high and very high sediment yields towards the south and east. The highest sediment yield is found in quaternary catchment A61G and A61F ranging between 69 000 t/a and 84 000 t/a respectively. These catchments are highly populated. Mogalakwena's main urban node Potgietersrus is also situated within A61G. Like Lephalale, the TDS loading found in Mogalakwena water resources is relatively low ranging between 0-500 mg/l.

In terms of groundwater resources, Figure 5-12 illustrates that 1 801 km² of the subsurface area has groundwater which is of good quality as the EC is below 70 mS/m. These regions are scattered throughout the municipality. The spatial data also indicates that 4 227 km² is of poor or bad groundwater quality ranging between 70 mS/m – 300 mS/m. Highly concentrated subsurface areas found beneath Potgietersrus, Mmamatlakala, and Sekuruwe adding up to 137 km² has very high EC ranging between 300 mS/m – 1 000 mS/m.

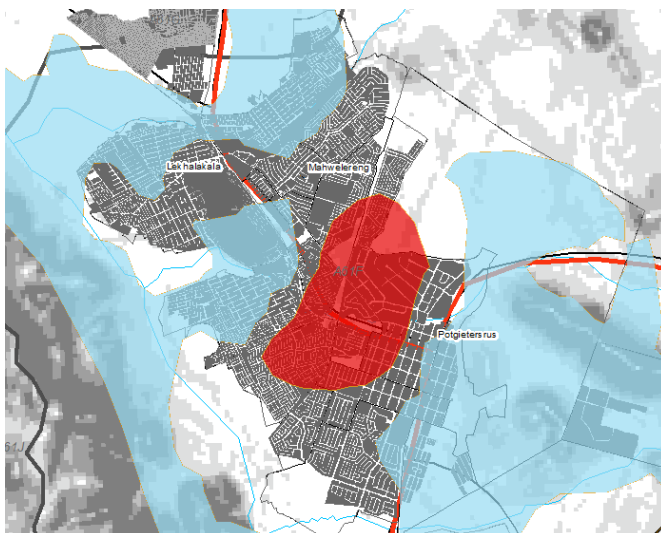


Figure 5-12: Irregular Groundwater EC

Source: Own Construction (2018)

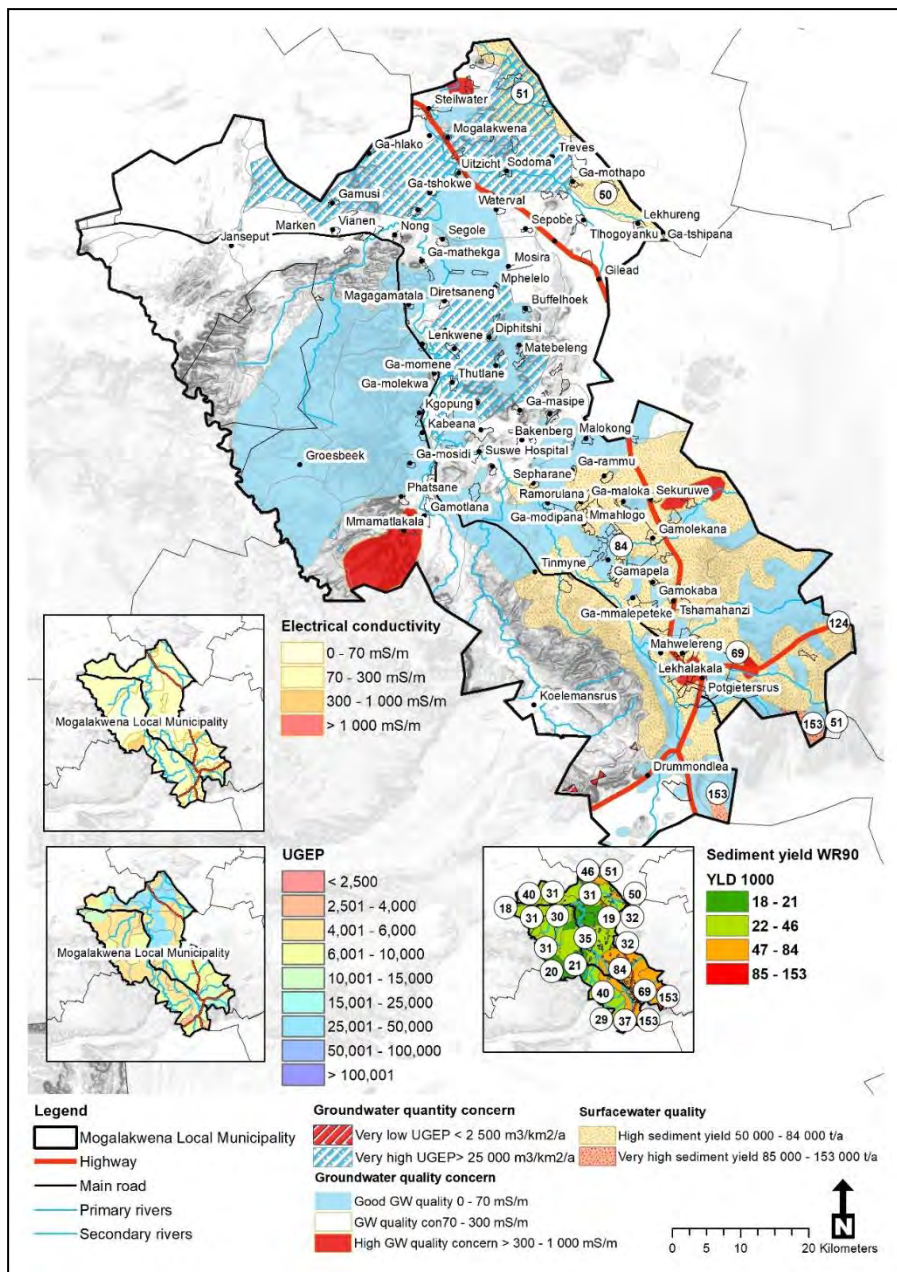


Figure 5-13: Mogalakwena's macro-scale quality and quantity analysis

Source: Own construction (2018)

Two major dams the Glen Alpine Dam and the Doorndraai Dam are located in Mogalakwena's river catchment. The Doorndraai Dam supplies water to Mokopane (Potgietersrus), whilst the Glen Alpine Dam provides the immediate and downstream area with water for both primary use and irrigation (Mogalakwena Local Municipality, 2018:64). According to the DWS spatial data on Cumulative Streamflow, Glen Alpine Dam cumulative neutralised streamflow is calculated at 236 000 000 m³/a whereas the present-day streamflow is calculated 114 000 000m³/a.

The assessment indicates that when land use is added, the cumulative neutralised streamflow (availability) is also reduced by more than half. Figure 5-13 illustrates that the UGEP is relatively low ranging between 2 500 m³/km²/a -15 000 m³/km²/a; and highly irregular throughout Mogalakwena Local Municipality. UGEP is lowest towards the western region, increasing slightly towards the north where patches of relatively high UGEP ranges between 25 000 m³/km²/a - 50 000 m³/km²/a. Diphitshi; Ga-Hlako, Ga-Malapile, Ga-Malope, Ga-Momene, Ga-Nkidikitlana, Ga-Ralenkwane, Ga-Tshokwe, Gamusi, Gataueatswala, Mabuladihlare, Matebeleng, Mogalakwena, Mphelelo, Nkwe, Setuphulane, Sodoma, Thutlane, Treves and Uitzicht are located within high UGEP areas.

Mogalakwena's existing SDF does not address any issues related to surface water of groundwater resources quality. In terms of water resource quantity, the SDF noted that Mogalakwena's constraints with access to local water sources for development are overcome by linking the municipal areas to the supply area of Lepele Water (Mogalakwena Local Municipality, 2009:17). However, the availability of groundwater for irrigation and other uses can have a very direct impact on development.

5.4.2.1.2.3 Macroscale water quality and quantity assessment: Key findings and conclusion

The quality and available quantity of water resources can have a major impact on the municipalities socio-economic development. In the case of Lephalale and Mogalakwena Local Municipality, catchments with high sediment yield and high TDS concentration should be prioritised for land use interventions including the revegetation and implementation of SUDS in sensitive areas, especially in river and wetlands buffer zone areas. Filtered strips alongside rivers and wetland buffers can reduce the amount of sediment deposits (see Section 4.3.1.2).

Groundwater resources are generally not addressed in spatial plans as it is a resource not visible to the naked eye. As mentioned previously, groundwater pollution is a major problem in South Africa as the impact of land activities on groundwater resources are poorly understood and contamination of groundwater sources can go undetected for a long time. The EC of groundwater is highly irregular in both municipalities making it difficult to establish a direct relationship between land use and groundwater quality impact. However, the spatial data makes it possible to identify spatial areas where additional studies related to the impact of land use on groundwater quality should be prioritised. Most of South Africa human settlements are becoming more dependent on groundwater resources, specifically in rural areas where fixed services are too expensive to operate. As such, rural settlements have become highly depended on groundwater resources.

For this reason, the spatial location of areas with high and low UGEP should be a determining factor for all future developments. Development on, or close to high UGEP should be managed very carefully to avoid any possible form of groundwater resource contamination. According to Section 4.3.1, detention ponds and retention basins should not be considered in areas with high-water table ($UGEP > 25\,000\text{m}^3/\text{km}^2/\text{a}$), or where soils are very coarse as there is a high risk of groundwater contamination. See further recommendations on how this analysis can inform municipal planning tools to achieve WSS as provided in Chapter 7.

5.4.2.1.3 Environmental protection, conflict and intervention areas

Legally proclaimed protected areas enjoy the highest level of protection from physical development. Ecosystems within protected areas are generally untouched and in good ecologically condition as the site-specific management thereof falls within the management responsibility assigned to provincial conservation authorities or institutions as discussed in Section 4.2.3.2. However, the National Biodiversity Framework identified the need to expand legally protected area to achieve the national biodiversity target (see Table 5-9). This is further expressed in the NPAES which set a 20-year target to increase the countries protected areas network by $255\,877\text{ km}^2$ consisting of:

- $104\,962\text{ km}^2$ marine benthic and coastal ecosystems;
- $146\,814\text{ km}^2$ terrestrial ecosystems;
- $2\,352\text{ km}^2$ wetlands; and
- $1\,490\text{ km}^2$ rivers.

The expansion should be informed by systematic biodiversity assessment which identifies areas of ecological significance. As noted in Section 4.2.3.2 the National Biodiversity Framework requires provinces to develop Provincial Spatial Biodiversity Plans which identifies critical biodiversity areas (CBA) and environmentally sensitive areas (ESA). Once identified, CBAs and ESAs call for a finer scale biodiversity plan which is the Bioregional Plan. The purpose of a bioregional plan is to inform land-use planning, environmental authorisation and natural resource management a range of sectors whose policies and decisions impact on biodiversity outside of protected areas. Since the publication of South Africa national freshwater ecosystem priority areas (FEPA) dataset – most Provincial Spatial Biodiversity Plans and Bioregional Plans have included FEPA as part of their CBAs and ESAs networks (see Section 4.4.2).

The purpose of this analysis is to determine the spatial location and extent of areas with specific management requirements, the impact of anthropogenic land uses on those areas, and the potential to expand the municipality's protected area network.

Table 5-15 describes the evidence based methodology used to identify the environmental protection and management requirements for both Lephalale and Mogalakwena local municipally.

Table 5-15: Environmental protection and management requirements methodology

Map	Determine the spatial location and extent of... Method / Steps
Waterberg Bioregional Plan	
All basemap data - A01 ; A02; A03; A04; A05; A06; A07; A08; A09; A10; A11; A12; A13; and A14 Infrastructure data - A20; A21; A22; A23; A24; A25; A26; A27; and A28 Protected areas - A51 Critical Biodiversity Areas (CBA's) - A52 Ecological Support Areas (CBA) - A53	...all areas which enjoy legal protection and conservation efforts ...all previously identified CBA and ESA in the municipality - Map A51, A52 and A53 as is. - The "Erase" tool in GIS and select A52 and A53 as the "Input Feature" and A51 as the "Erase Feature" to determine the remaining CBA's and ESA's outside of all Protected areas. - Add the land use data as captured in the land audit process. - Urban land use - Village land use - Agricultural land use - Mining land use - Use the "select by location" tool in GIS to select all "urban land use"; "village land use", "Agriculture" and "Mining" as "Target Layers" and select each of the PA; CBA and ESA as "Source Layer" to identify where land use has affected protected areas, CBAs and ESAs areas. - Once selected, export the data to and create the following new shapefiles: "Modified PA.shp" "Modified CBA ESA.shp" - Export the remaining untouched CBAs and ESAs and label it: "Untouched CBA ESA network.shp"
National Freshwater Ecosystem Protection Areas	
Add to the above Rivers FEPA - A54 Wetland FEPA - A55 Wetland Clusters - A56	...river conditions within the municipality and the management requirements as per the NFEPA guideline ...wetland FEPA and wetland clusters within the municipality - Use the "Ring Buffer" tool in GIS to create a 100m, 200m, 500m, 1000m and 2000 m buffer zones for all rivers FEPA, wetlands and wetlands clusters. - Use the "select by location" tool in GIS to select all "urban land use"; "village land use", "Agriculture" and "Mining" as "Target Layers" and select each of the all rivers FEPA, wetlands and wetlands clusters as "Source Layer" to identify where land use, water quality and quantity conflict areas. - Once selected, export the data to and create the following new shapefiles: "Modified FEPA rivers.shp" "Modified Wetland Clusters.shp" - Export the remaining untouched FEPAs and label it "FEPA Buffer zone" - Create a 2 km buffer zone using the "Buffer" tool in GIS. - Use the "Clip" tool in GIS, select the "Untouched CBA ESA network.shp" as the "Target Layers" and Protected areas Buffer.shp as the "Source Layer" to clip areas to form part of the Protected Areas Expansion strategy. - Use A54; A55 and A56 as an overlay and to determine which areas should be prioritised as they include valuable freshwater ecosystems. - Use the A18 (Cadaster.shp) and select manually all erf portions located within the CBA and ESA 2 km buffer zone and has FEPAs and Wetland clusters. - Once selected, export the data and create a new shapefile and label it "Potencial NPAES.shp"

Final Map	
Map the following Waterberg Bioregional Plan • Modified PA • Modified CBA ESA • Untouched CBA ESA network National Freshwater Ecosystem Protection Areas • Modified FEPA rivers.shp • Modified Wetland Clusters.shp • FEPA Buffer zone	... all ecologically stable areas ... all ecological conflict areas 16. For reporting purposes, use the “ Calculate Geometry ” function to determine the physical extent (km ²) of the all ecological conflict areas. 17. Use the “Spatial growth.shp” to visually inspect areas where natural growth trends to grow towards ecologically stable areas.

Source: Own construction (2018) see Annexure E for data source list.

Section 5.4.2.1.3.1 and Section 5.4.2.1.3.2 to follow summarises and spatialise the key findings of the environmental management areas assessment for Lephalale and Mogalakwena Local Municipality. Section 5.4.2.1.3.3 reflects on the key findings and draws a conclusion.

5.4.2.1.3.1 Lephalale environmental management areas

More than 4 834 km² of land in Lephalale Local Municipality is declared as protected areas under the National Environmental Management Act: Protected Areas (Act no. 57 of 2003). According to the spatial data, 3 080 km² thereof forms part of the Waterberg Biosphere Reserve, 1 472 km² is declared Nature Reserves, while 281 km² is declared National Park. According to the Waterberg Bioregional Plan’s spatial data, 5 491 km² outside of the legally protected areas have been identified for having ecological significance. 3 952 km² of which has been classified as CBA which includes irreplaceable sites; critical linkage in biodiversity corridors; areas identified in existing plans and other important sites. While the remaining 1 539 km² has been identified as ESA, which includes important habitats, biodiversity corridors (promoting ecological connectivity) and protected areas buffers. CBAs and ESAs also include aquatic features as identified in the NFEPA dataset.

The NFEPA dataset provides spatial information in the condition of rivers, their sub-catchment management status, and the spatial location and extent of wetland clusters. According to the NFEPA spatial dataset, 467 km² of the municipality river network is in good ecological condition (category A, AB and B). These rivers sub-quaternary catchments gained the management status of Rivers-FEPA. Although the FEPA status applies to the actual river reach within the area, the surrounding land and smaller stream networks need to be managed in a way that maintains the good condition.

Unfortunately, several of the major river networks have been moderately or largely modified which includes amongst others the Lephalala; Limpopo; Mamba; and Matlabas river network.

In terms of wetland water bodies, the NFEPA spatial dataset indicates that several existing wetlands are located within close proximity, in relatively natural landscapes, forming groups of embedded wetland waterbodies. These groups are referred to as Wetland Clusters and provide critical ecological process. According to the NFEPA spatial data, 66 Wetland Clusters covering 1 287 km² of surface area (includes the extent of the 100 m, 250 m, 500 m, 1000 m and 2000 m buffer zones) can be found within catchment A41C and A41E. Although the spatial data indicates that the municipality is rich in environmental resources, land use activities have led to the degradation or destruction of many of the above-mentioned areas of ecological significance. In terms of the land use environmental conflict areas, the spatial data indicates that a total of 128 km² of protected area is affected by 124 km² of agriculture, 3.3 km² of mining, 0.9 km² of urban and 0,008 km² of rural land use. These areas are illustrated in red as Modified PA (Protected Areas) in Figure 5-14.

In terms of CBA and ESA networks, the spatial analysis revealed that 611 km² has been affected by 491 km² of agriculture, 3.5 km² of mining, 42.6 km² of urban and 45 km² of rural land use (see Figure 5-14). The spatial analysis also revealed that 32.7 km² of Lephalale's FEPA river network and buffer zone has been impacted by 23.0 km² of agricultural, 1.5 km² of mining and 8.08 km² of urban land use. The land audit data revealed that 45.1 km² of wetland clusters surface area has been affected by 39.9 km² of agricultural; 0.28 km² of mining; 3.1 km² of urban and 1.7 km² of rural land use.

Figure 5-14 makes it relatively clear that the majority of wetland clusters in Lephalale Local Municipality is affected by agricultural activities towards the south-western region and informal settlement development towards the north-east. These areas have been highlighted; Modified Rivers FEPA and Modified Wetland Clusters. In terms of urban and rural land uses, the spatial data revealed that 3 328 of urban and 132 of rural land use parcels are in direct conflict with wetland clusters. While another 7 072 of urban are found within the Rivers FEPA buffer zone.

As a result, the spatial assessment revealed that 96% (or 5 374 km²) of the original 5 585 km² of CBA and ESA network remains untouched and in good ecological condition. In terms of Wetland Clusters and Rivers FEPA's, of the original 3 069 km² (including buffer zones), 97% (or 2 996 km²) thereof remain in good ecological condition. With the aim of contributing to the NPAES,

Figure 5-14 identified 109 farm portions covering 639 km², within a 2 km radius of existing protected areas, unaffected by land use to date, have an assigned CBA status and most importantly have either Wetland clusters or River FEPA found within them. By adding 639 km² to the municipalities existing Protected Areas Network, the proportion of ecologically sensitive areas (specifically wetland clusters and River FEPA) under legal protection will increase by 13.6%.

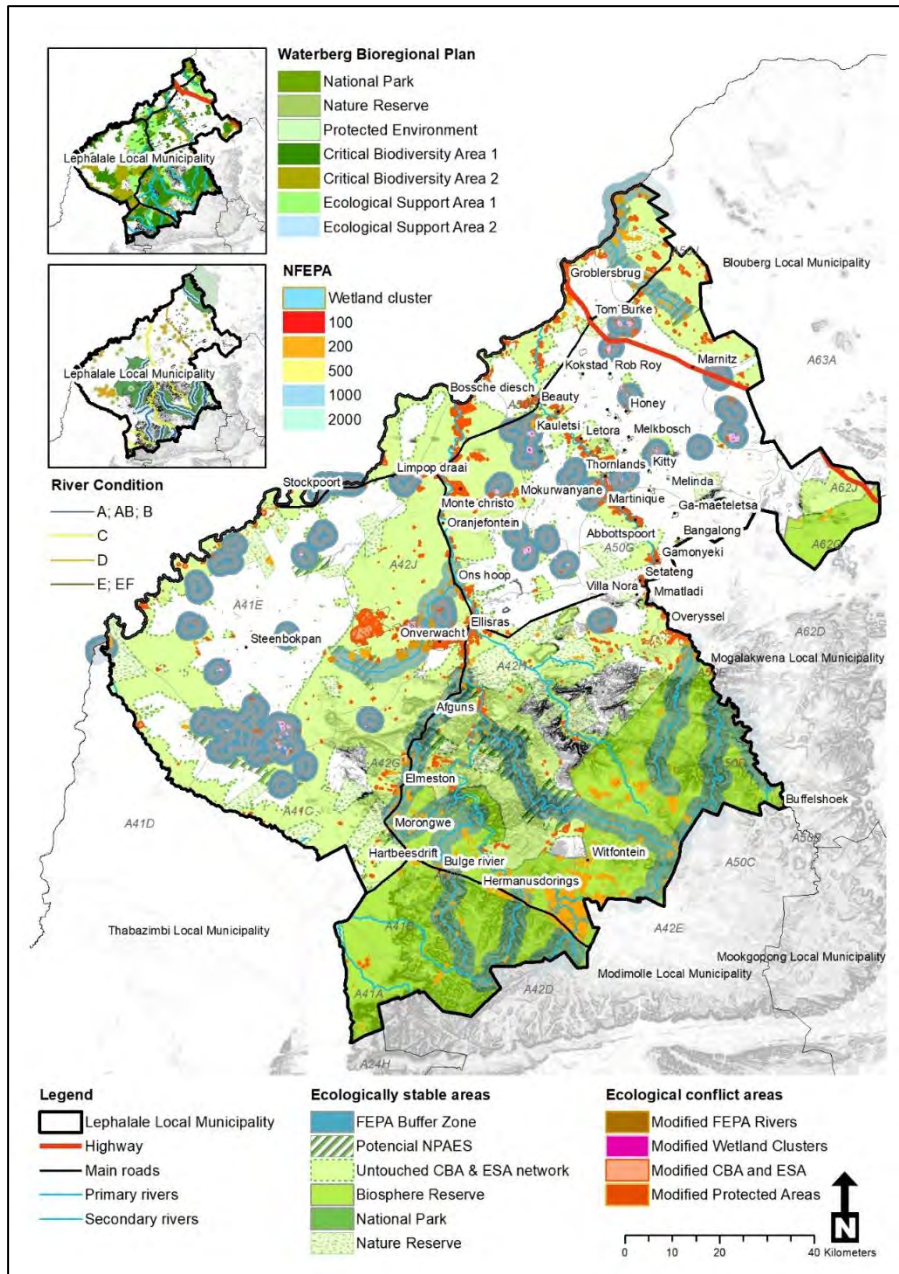


Figure 5-14: Environmental Management Requirements

Source: Own Construction (2018)

Lephalale's existing SDF should be credited for referencing the Waterberg District Bioregional Plan (2016) in several sections throughout the document (Lephalale Local Municipality, 2017a). Firstly, the existing SDF acknowledges the Waterberg District Bioregional Plan (2016) as part of its policy analysis (Lephalale Local Municipality, 2017a:25-26) and refers to the land use guidelines as assigned to CBA's and ESA's. The SDF biodiversity analysis includes a map representing all Protected areas, CBA's and ESA's found within the municipality. It also noted the important role of the Biosphere Reserve (Ibid.).

However, the existing SDF does not address any land use impact on the CBA's and ESA's and therefore assumes that all CBA's and ESA's are in good ecological condition, which in reality is often not the case (as proven in the assessment). Although not identified spatially, the SDF does recommend that further loss of natural habitat should be avoided in these areas; that degraded or disturbed CBA's and ESA's are prioritised for rehabilitation through programmes such as working for water and Working for wetlands; and, maintain landscape connectivity by avoiding loss/degradation of CBAs and ESAs, especially in corridor pinch-point. The existing SDF is silent on FEPA's specifically.

5.4.2.1.3.2 Mogalakwena environmental management areas

Mogalakwena Local Municipality has more than 605 km² of land declared as protected areas under the National Environmental Management Act: Protected Areas (Act no. 57 of 2003). According to the spatial data, 422 km² is declared Nature Reserves whereas the remainder, 183 km² is declared World Heritage Sites. According to the Waterberg Bioregional Plan's spatial data, 3 900 km² outside of the legally protected areas have been identified for having ecological significance. 2 954 km² of which has been classified as CBA, while the remainder 945 km² as ESA.

In terms of FEPA, 29 km of the Mothlakole river network is located within a Sub-quaternary catchment which gained the management status of Rivers-FEPA. As noted in Section 5.4.2.1.3.1, although the FEPA status applies to the actual river reach within the area, the surrounding land and smaller stream networks need to be managed in a way that maintains the good condition. As for the rest of the Mogalakwena's river networks, 128 km is in good ecological condition (category A, AB & B), 435 km in somewhat modified (Category C), while 183 km has been heavily modified and is now in ecological condition D. The DWS's spatial data indicates that Mogalakwena Local Municipality has more 1 020 wetland water bodies covering an estimated surface area of 37.2 km².

However, the NFEPA spatial dataset indicated that unlike Lephalale, Mogalakwena Local Municipality only has 4 wetland clusters covering a surface area of 206 km² (includes the extent of the 100 m, 250 m, 500 m, 1000 m and 2000 m buffer zones).

In terms of the land use environmental conflict areas, the spatial analysis revealed that a total of 33.6 km² of Protected Area is affected by 21.4 km² of agriculture, 0.71 km² of mining, 1.4 km² of urban and 1.5 km² of rural land use. These areas are illustrated in red as Modified PA (Protected Areas). In terms of CBA and ESA networks, the spatial analysis revealed that 682 km² has been affected by 409.7 km² of agriculture, 16.2 km² of mining, 31.8 km² of urban and 113.6 km² of rural land use. Even though 128 km of Mogalakwena's river network is considered to be in good ecological condition A, AB or B, the spatial analysis revealed that 44.3 km² of river FEPA and their buffer zones have been affected by 41.9 km² of agricultural, 0.29 km² of mining, 1.6 km² of urban and 0.14 km² of rural land use.

Although Mogalakwena only has 4 wetland clusters, the spatial analysis calculated that 38 km² thereof is affected by anthropological land uses. The land audit data revealed that wetland clusters are affected by 12.7 km² of agricultural; 0.09 km² of mining; 16.1 km² of urban and 9.4 km² of rural land use. Clearly, urban land uses are causing the most damage to wetland clusters (see Figure 5-15).

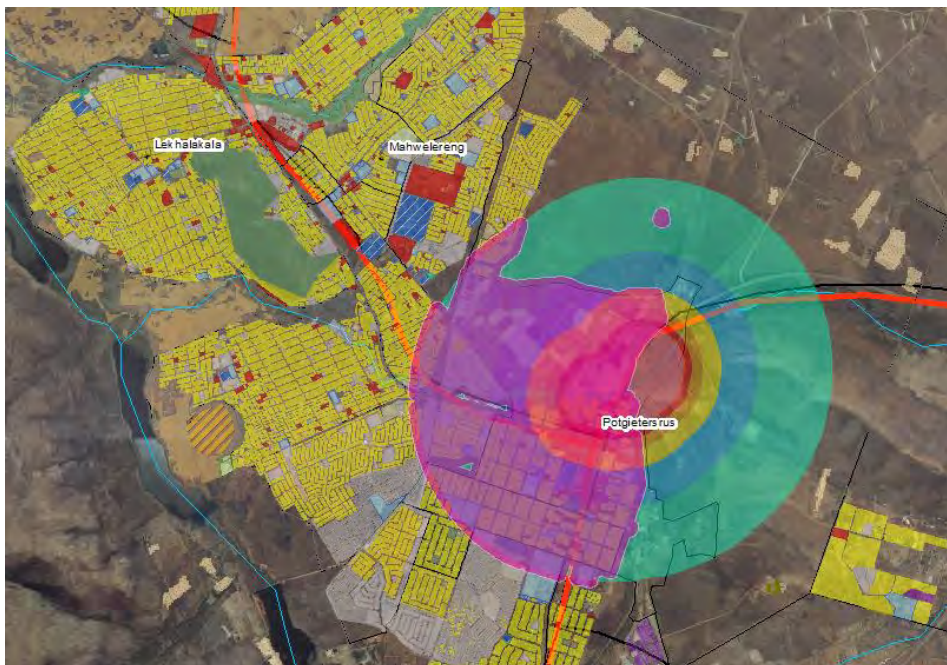


Figure 5-15: Modified Wetland Clusters

Source: Own construction (2018)

In terms of environmental management opportunities, Figure 5-16 illustrates the spatial location of remaining FEPA buffer zones; Wetlands FEPA buffer zones; CBA and ESA in good ecological condition and Protected areas. These areas should be managed according to the land use management guidelines as set out in the Waterberg Biodiversity Plan as well as the Manual for Implementation manual for Freshwater Ecosystems Priority Areas (Driver *et al.*, 2011:69-90). Figure 5-16 also identified 3 900 km² of land, with either a CBA or ESA management status, within a 2 km radius of existing protected areas which could potentially be included as part of the NPAES.

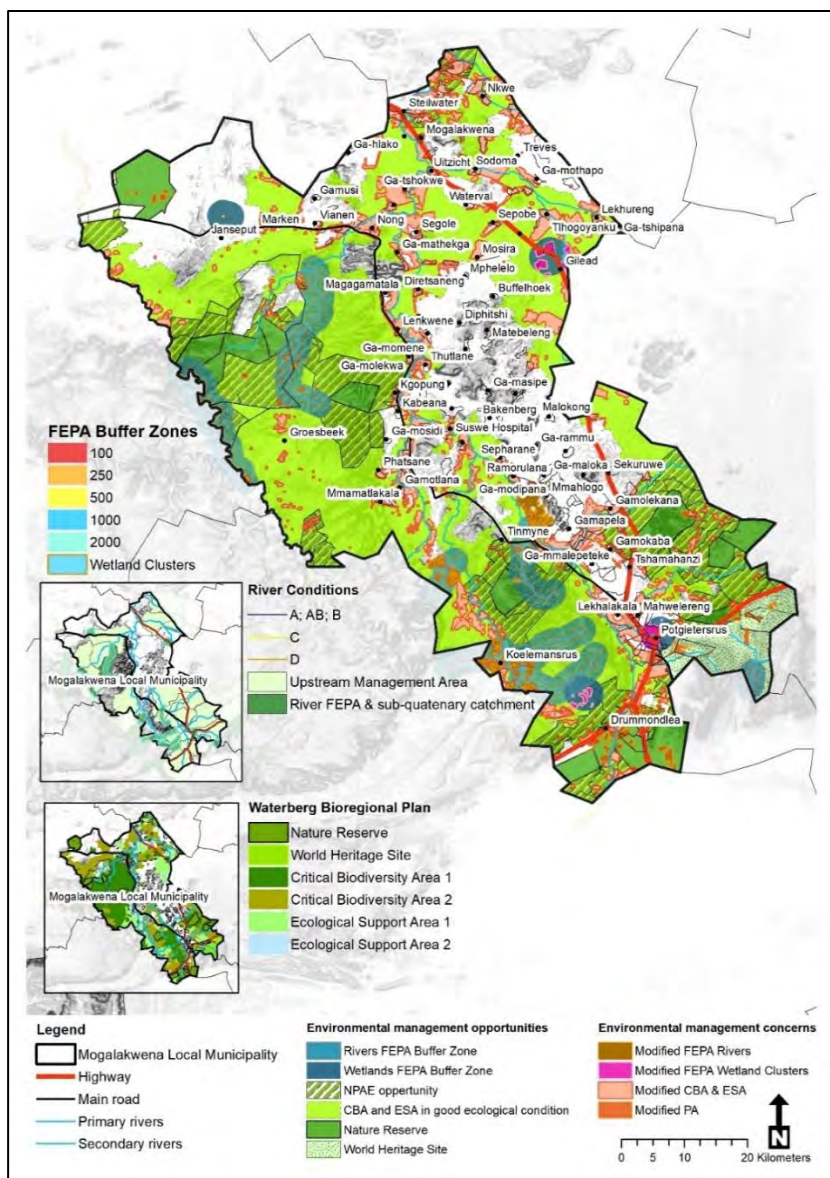


Figure 5-16: Mogalakwena environmental protection, conflict and intervention areas
Source: Own Construction (2018)

Mogalakwena's existing SDF addressed the extent of the biosphere and conservation areas and recognised that ecological issues go way beyond the demarcation of biospheres and key environmental features (Mogalakwena Local Municipality, 2009:23-27). As for CBAs and ESAs, the 2009 Mogalakwena SDF was published prior to the Waterberg District Bioregional plan and therefore does not include any reference to CBAs or ESAs. The Mogalakwena SDF was also published prior to the 2011 NFEPA spatial dataset and is therefore also not included.

5.4.2.1.3.3 Environmental protection, conflict and intervention areas: Key findings and conclusion

The evidence based spatial analysis provides valuable insights as to where (location) and how much of the municipalities landscape associated with ecological importance has been affected or destroyed by development. In essence, the analysis revealed that in Lephalale Local Municipality 2.65% of Protected areas; 11.13% of CBA and ESA; 7% of the municipalities FEPA river systems; and, 3.50% of FEPA wetland cluster has been affected by development. In Mogalakwena Local Municipality the assessment revealed that 5.56% of Protected areas; 17.49% of CBA and ESA; 7.28% of the municipalities FEPA river systems and 13.2% of FEPA wetland clusters spatial extent has been affected by development. These areas should be of high concern to both municipalities.

In both municipalities, the percentage of affected areas of ecological importance is relatively low which makes prioritisation of rehabilitation projects easier. Strategic Objective (2) of the National Biodiversity Strategy and Action calls for "Investment in ecological infrastructure enhance resilience and ensures benefits to society" (SANBI, 2014b) (see Section 3.6.3). This topic has become an emerging area of interest in South Africa and in 2014, SANBI in association with various national departments published a Framework for Investing in Ecological Infrastructure in South Africa. The benefits of investing in ecological infrastructure include (amongst others) a lengthened lifespan of built water infrastructure and reduce maintenance cost, reduces soil erosion and soil degradation and supports food security, buffer settlements from storms and surge events and ecosystems will assist with adapting to climate change (Ibid.:5-7).

However, as seen in the evidence based analysis, the spatial location of ecological infrastructure is often located in municipalities rural areas, on private or communal land where landowner themselves are often not receiving the full benefit of the services and will, therefore, tend to under-invest. These landowners, specifically in Lephalale and Mogalakwena Local Municipality are unable to afford the necessary investment (cash) that is required for the large scale and often relatively complex interventions that may be needed in the landscape.

However, Government has several incentive programs in place through which optimal investment in ecological infrastructure can be achieved. Through the evidence based spatial analysis, municipalities will be able to prioritise certain areas and communities to become custodians of biodiversity stewardship programs.

The evidence based analysis also addressed national governments agenda to expand the countries protected areas network - as called for in the National Protected Areas Expansion Strategy (see Table 5-9). The analysis identifies 639 km² of land in Lephalale and 3 900 km² of land in Mogalakwena Local Municipality which can potentially be included in the protected areas network as it contains a proportion of ecologically sensitive areas, within a close proximity to existing protected areas and has priority FEPA found within. See further recommendations on how this analysis can inform municipal planning tools to achieve WSS as provided in Chapter 7.

5.4.2.2 Water Sensitive Built Environment Analysis

Based on this study's literature review, it is evident that land use has both a water resource quality and quantity impact which should be assessed spatially as part of the Water Sensitive Built Environment Analysis. The Water Sensitive Built Environment Analysis has a vital role to play in achieving cities/settlements as water catchments and providing ecosystems services.

5.4.2.2.1 Land use water quantity impact

The quantitative impact of land uses on water resource refers to the physical consumption of water. The concept is much easier to grasp than the qualitative one, as people and economies require water to function. Thus, it's safe to say that the use of water, driven by human needs, can be traced back to specific land use such as residential, business, agricultural or industrial. The aim of this analysis is to determine the spatial extent of water demand by land use and to determine to what extent this demand can be substituted by rainwater harvesting technologies and other WCWDM strategies. Most, if not all, municipalities in South Africa uses a billing system where consumption of various services is recorded. The purpose of this modelling exercises it to determine the land use water quantity impact by linking land use (which has been identified during the land audit process) to the municipal water billing information. This spatial modelling exercise helps to identify which land use consumes the highest volumes of water and where water consumption interventions should be prioritized. The evidence based modelling exercise also assists in identifying individual properties which have irregular high water consumption patterns which could be a result of either inappropriate use, physical leakage or billing errors.

The analysis also provides some level of understanding of future water demand by land use which should be used to inform future development applications. Like the previous assessments, this analysis can also help to inform water conservation and demand management strategies through which the municipality can contribute to achieving the NDP's target to reduce urban water demand below 15% from business as usual (see Table 5-9).

The second part of this analysis, investigates the potential for rainwater harvesting on an urban scale as a possible technique for optimizing the use of available rainfall in any given urban location. The microscale rainwater harvesting potential analysis should be used to broaden water services authority's classification of an appropriate level of service to be provided to communities. Specifically, to those communities unable to pay for services, sparsely populated, located far away from existing fixed infrastructure, and has limited economic or growth potential making water services delivery through fixed infrastructure impractical and too expensive.

The utilisation of alternative water resources is one of the key pillars of practice of water sensitive cities/settlements. Table 5-16 describes the evidence based methodology used to conduct a land use water quantity assessment for both Lephalale and Mogalakwena Local Municipality.

Table 5-16: Land use water quantity assessment methodology

Map	Determine the spatial location and extent of... Method / Steps
All basemap data - A01 ; A02; A03; A04; A05; A06; A07; A08; A09; A10; A11; A12; A13; and A14 Infrastructure data - A20; A21; A22; A23; A24; A25; A26; A27; and A28 Land use data - As per settlement scale land audit. Municipality billing information - As per municipal billing system.	...the land use water quantity impact (the volume of water consumed per land use) - Obtained municipal billing information – extract a years' worth of transactions. - Convert the billing system information to excel format/ spreadsheet; - Identify information in the Excel spreadsheet representing the physical location of the property billed and the volume of the water consumed per property which can be linked to the land use spatial data (e.g. unit number, erf number or SG code). - Once identified, use the “Join and Relate” function in GIS join the excel billing data, using the “unit number” or “erf number” to link the land use dataset. - Once joined, use the “Symbology” – “Quantities” – “Gradated Colour” by “Equal Interval (4 Classes)” to differentiate between the average monthly water consumption (e.g.): 0-50 Kilolitres per month 51-100 Kilolitres per month 101-200 Kilolitres per month 201 – 300 Kilolitres per month 301+ Kilolitres per month
Rainwater harvesting potential – Urban Analysis takes place in Excel (no mapping)	... the volume of rainwater harvesting potential if all existing and future buildings in formal areas considers rainwater harvesting technologies. The following model (see description below) was developed (by the author) to calculate the rainwater harvesting potential of a settlement. The

	proposed method was adapted from after Wilson <i>et al.</i> (2004) and Woods-Ballard <i>et al.</i> (2007).
Final Map	
Land use water conservation and demand management zones	...spatially identify where water conservation and demand management strategies should be priorities. 7. A "New Shapefile" was created and labelled "WCDM_zone" which represented the spatial location of an overlay – to be prioritised for water audits and the implementation of water conservation strategies.

Source: Own construction (2018) see Annexure E for data source list.

Urban rainwater harvesting potential - The equation to calculate the rainwater harvesting potential of an individual site is relatively simple (Wilson *et al.*, 2004):

$$V = R \times A \times C \times FE$$

Where:

V = Volume of useable rainwater (l)
 R = Average rainfall over a period (mm)
 A = Area contributing to runoff (m²)
 C = Run-off coefficient (0-1)
 FE = Filter efficiency (0-1)

However, calculating the optimal rainwater harvesting potential (volume of useable rainwater (V)) for multiple stands or a settlement, without building footprints information requires a slightly different yet innovative approach. To determine V (*Volume of useable rainwater*) for an entire settlement, the following data should be gathered.

Daily rainfall data for the entire year for the specific areas should be obtained from the South African Weather Services (at a financial cost) (see Annexure F)

Land use data/cadastral as captured during the land audit proses provide spatial information on the land use, the zoning and the erf size of all formally registered properties in the municipality. However, it does not provide the m² of the area contributing to runoff (A) also referred to as the roof size of the building footprint. To determine (A) the calculation assumes that the full coverage as assigned by the land use scheme has been built. e.g. Figure 5-17 highlights Erf 834 which is 329 m² and zoned Residential 1. According to the scheme clauses, the coverage for residential land use in Lephalale is 60% and for residential stands smaller than 350 m² the maximum coverage is 50%. Therefore only 50% of erf 834 may be used for building purposes. In this specific example, only 164.5 m² of the total erf size can potentially contribute to runoff. As this calculation assumes that the full allowable coverage area has been built, the author changed (A) to (AA) representing the assumed area contributing to runoff (m²).

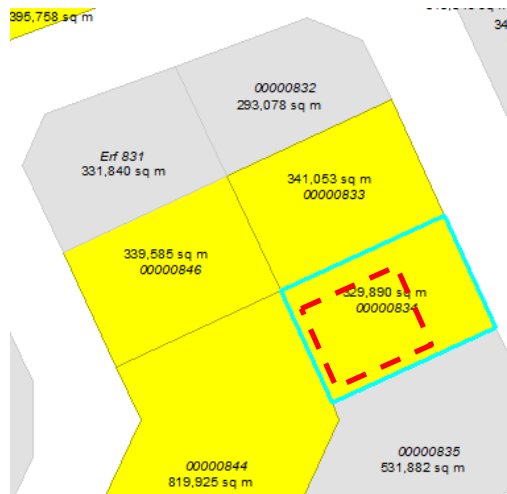


Figure 5-17: Area contributing to runoff – scheme coverage

Source: Own Construction (2018)

The following equation was used to calculate the total assumed area (m²) contributing to runoff.

$$AA = (ES \times Cov) - vacant$$

Where:

AA = Assumed area contributing to runoff (m²)

ES = Erf Size (m²)

Cove = % coverage as assigned by the land use scheme

Vacant = all vacant stands

The runoff coefficient (C) is the realistic proportion of rainfall runoff that enters the specified storage facility Table 5-17. For this specific calculation, a runoff coefficient was assumed to be 0.85.

Table 5-17: Runoff coefficient

Roof classification	Runoff coefficient C
Pitched roof, tiled	0.85
Flat roof tiled	0.6
Flat roof, gravel	0.4
Extensive green roof	0.3
Intensive green roof	0.2

Source: Wilson *et al.* (2004)

The filter efficiency refers to the proportion of water post filtration available for use. Generally, manufacturers recommend a conservative 0.9. Since daily rainfall data was available, the optimal daily rainfall potential could also be calculated.

$$V = ADR \times AA \times C \times FE$$

Where:

V = Volume of useable rainwater (l)

ADR = Average daily rainfall (mm)

AA = Assumed Area contributing to runoff (m²)

C = Run-off coefficient (0-1)

FE = Filter efficiency (0-1)

Section 5.4.2.2.1.1 and Section 5.4.2.2.1.2 to follow summarises and spatialise the key findings of the land use water quantity analysis conducted for Lephalale and Mogalakwena Local Municipality. One of the limitations to this analysis is that there is no billing information available for informal settlements and thus cannot be mapped. Calculating the rainwater harvesting potential of a municipality was also limited to the urban environment as building footprint information or zoning information is non-existing in the informal areas. Section 5.4.2.2.1.3 reflects on the key findings and draws a conclusion.

5.4.2.2.1.1 Lephalale urban land use water quantity analysis

The land use water quantity analysis for Lephalale's formal built-up areas was calculated as an average annual consumption rate/volume. Lephalale Local Municipality uses the Sebata Financial System, Table 5-18 provides an extract of the "raw" state of billing information.

Table 5-18: Extract - Lephalale Local Municipality Sebata Billing System Data

Erf number	Account	Physical meter no	Calcparm	Reading	Date	Average Monthly Consumption
0000/0255/00003962/00000/000	109686	654689	W	1571	2016/07/04	1320.08
0001/0001/00000001/00000/000	2	3197	W	89	2016/07/10	83
0001/0001/00000002/00000/000	4	3205	W	74	2016/06/30	81.85
0001/0001/00000003/00000/000	114489	985535	W	4224	2016/07/10	39.05

Source: Lephalale Local Municipality uses the Sebata Financial (2016)

One of South Africa's most common water-related challenges is incorrect or lack of billing information. According to the land use and billing information, of the 33 713 registered land parcels, the municipality only receives billing information for 31% thereof. The remaining 69% include areas used for agricultural or mining purposes which most likely received water services from other Water User Associations.

In terms of the municipality's 28 092 formally registered urban erven, the Sebata Financial System has recorded billing information for only 8 938 erven. This means that 68,18% of the municipality's formally registered erven remains unbilled. This corresponds with the DWS statistics on non-revenue for Lephalale Local Municipality which increased between 2008 and 2010 from 13% to 16% (DWS, 2018).

In terms of billed consumed volume, Lephalale Local Municipality's average monthly billed consumption is calculated at 2 398 091 kl which equates to an estimated 268 kl per erf (see Table 5-19). The spatial analysis revealed that more than 76.90% of water is consumed by residential stands. On average, a single house on a stand in Lephalale consumes 275 kl per month. Business, Community, Educational and Government are the biggest water users per stand ranging between 1 800 kl and 2 000 kl of water per stand. Table 5-19 summarises the average monthly land use water demand for Lephalale's Local Municipality formally registered and billed land.

Table 5-19: Ellisras water consumption by land use

Land Use	Total monthly consumption (kl)	No of Properties	Kl/Erf - Lephalale
Business Purposes	136 572	135	1 012
Community Purposes	22 506	20	1 125
Educational Purposes	34 908	17	2 053
Government Purposes	10 854	6	1 809
Industrial Purposes	8 783	31	283
Institutional Purposes	1 266	4	317
Municipal Purposes	5 921	36	164
Parking	200	4	50
Private Open Space	1 822	7	260
Public Open Space	1 451	20	73
Public Services Infrastructure	1 313	7	188
Residential Purposes	1 844 245	6 707	275
Roads	1 812	16	113
Special Purposes	219	2	110
Vacant	326 169	1 925	169
Billed properties	2 398 091	8 938	268

Source: Own Construction (2018)

Figure 5-18 and Figure 5-19 reveals Lephalale's land use water quantity impact spatially. Figure 5-18 provides a 3D (three dimensional) view of the land use water quantity impact to better depict the multiple variables. Furthermore, the various colours represent land uses (e.g. yellow = residential; red = business, purple = industrial) whereas the height of the “skyscraper” represents the average monthly water consumption of the specific property. This clearly indicates that the bulk of water consumption on a monthly basis is consumed in the central business areas of the municipality as well as by institutional land uses.

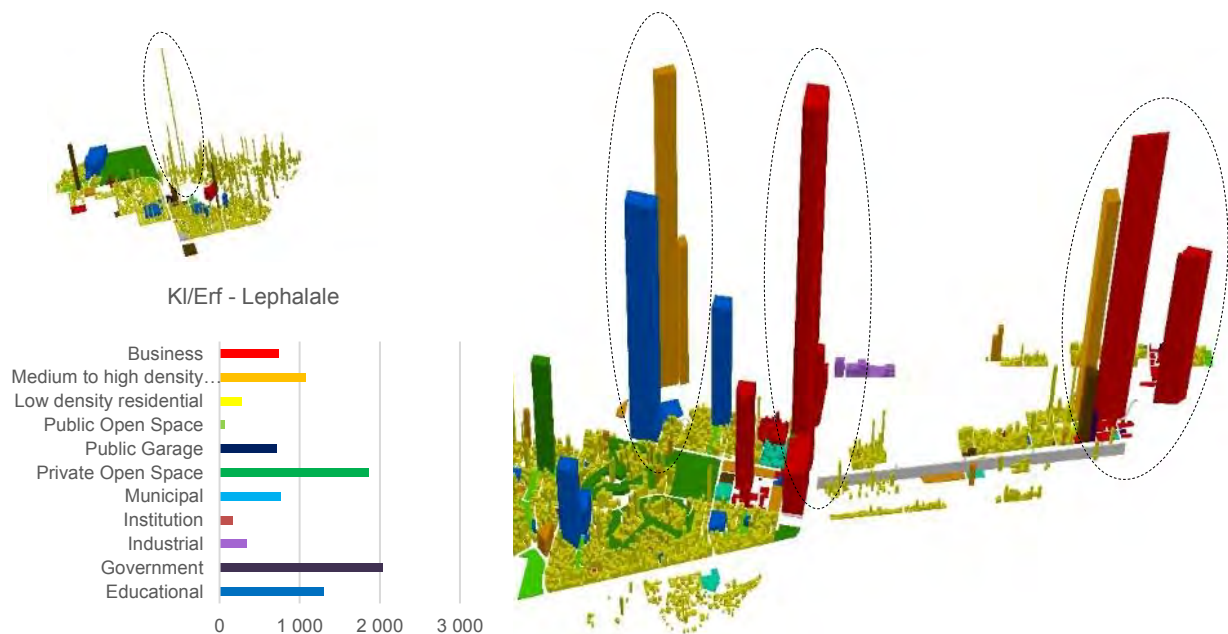


Figure 5-18: 3D Lephalale monthly water consumption per land use

Source: Own Construction (2018)

From the above spatial analysis, it becomes clear that certain individual land uses have irregular high-water demand. This trend could be the result of incorrect billing information, leaking pipes or illegal land use (e.g. the residential land use with irregular high-water demand identified in the left corner in Figure 5-18 might have a car wash or other illegal business taking place).

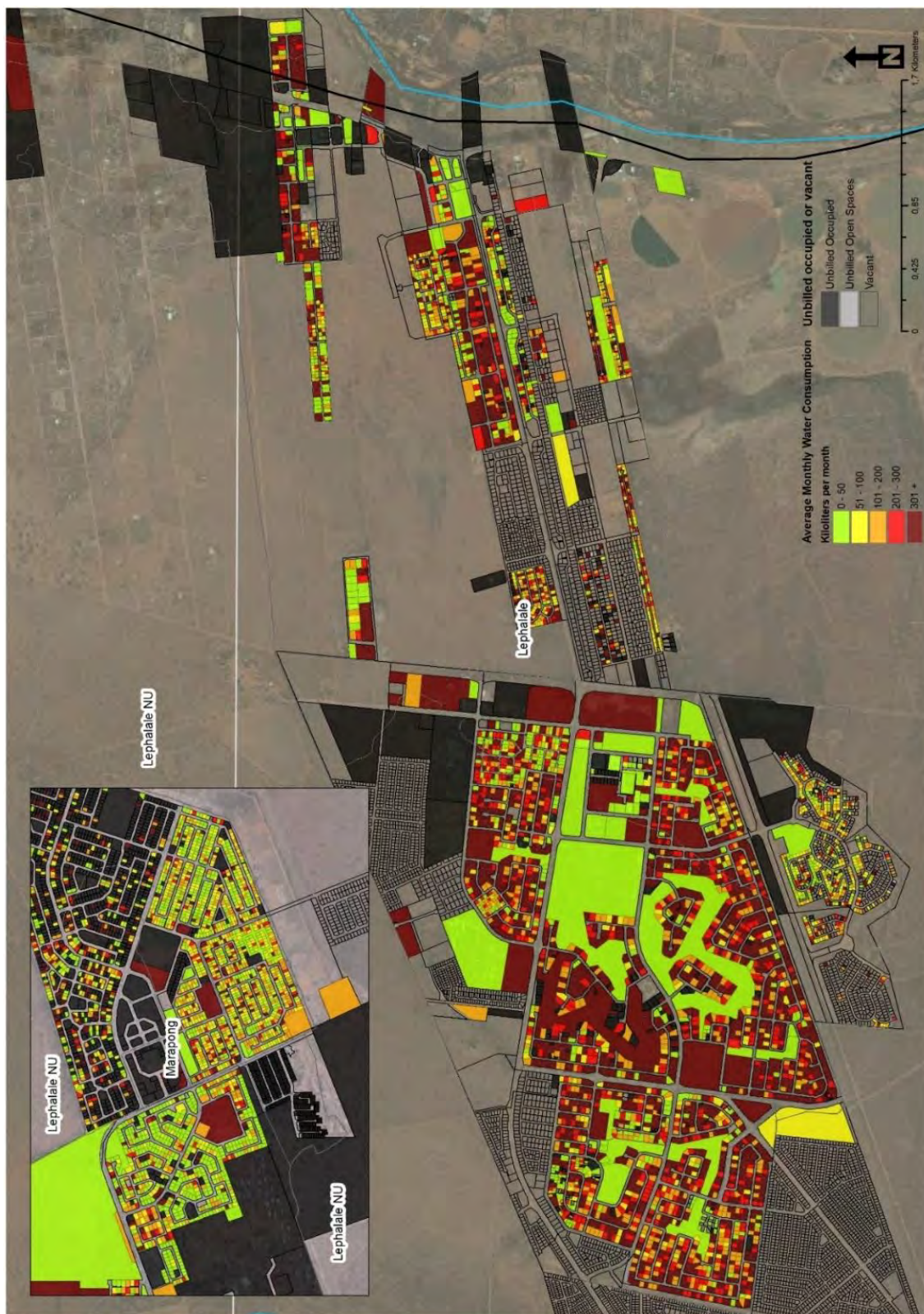


Figure 5-19: Lephalale average monthly water consumption

Source: Own Construction (2018)

Figure 5-20 identified several zones where WCWDM should be priorities. The WCWDM zone covers 716 erven, a small 8% of the municipality's formally register and billed erven. Most of the selected erven (not all) have an average monthly water consumption of more than +301 kl which amounting to a total monthly volume of 496 913 kl, 21% of Lephalale's total monthly water consumption. The NDP has a set target is to reduce the urban water demand by 15% by 2030. The WCWDM zone as illustrated in Figure 5-20 can facilitate the municipality to achieve this target by proposing the following:

- All land uses (only 716 erven) affected by the WCDM zone MUST reduce their monthly water demand by 30% and all other land use should reduce their demand by 10%.
 - o Table 5-20 explains that if all 716 erven (currently identified as having an irregular high-water demand) reduce their monthly water demand by 30%, a monthly water savings of 149 074 kl (6.22% of the existing consumed volume) can be achieved.
 - o In addition, the remaining 8 223 urban land use should reduce their monthly water demand by 10%. This will amount to an additional water savings of 190 118 kl (also calculated as 23 kl per erf per month).
 - o All in all, a total monthly water savings of 339 192 kl can be achieved. In terms of the NDP's target – Lephalale Local Municipality can reach a 14.14% reduction in water consumption (below business as usual). This can be achieved through:
 - good housing - retrofitting old faucets with water-saving faucet (immediate saving of up to 25%);
 - onsite greywater reuse or water harvesting;
 - The municipality can charge more for water if they use more than which is considered appropriate (Flexi tariff); or
 - the municipality can implement a trickle flow strategy.

Table 5-20: Spatial targeted strategy to reduce water demand

Spatial areas	Total monthly consumption (kl)	WCDM target	Potential savings (kl)
Sum of total water demand in WCDM zone (kl)	496 913	30%	149 074
Sum of total water demand in Lephalale (kl) excluding demand in WCDM zone	1 901 178	10%	190 118
Sum of total water demand in Lephalale (kl)	2 398 091		
NDP target 14,14%			339 192

Source: Own Construction (2018)



Figure 5-20: Lephalale WCDM Intervention Zone

Source: Own Construction (2018)

As for Lephalale's rainwater harvesting potential, based on the proposed methodology the following finding for Lephalale's main urban (Ellisras) node was made. Lephalale Local municipality's daily rainfall information was obtained from the SA Weather services (see Annexure F). According to the daily rainfall data, Ellisras only received 228.2 mm of rain for the entire year.

The analysis assumed that each property in Ellisras has a building footprint equal to that of its legal coverage (e.g. 60% of a residential stand is covered by a roof). Using the zoning information and size of each land parcels the "assumed" areas contributing to runoff (AA) was calculated in GIS. Two scenarios were created:

- Scenario 1 assumes that the total assumed areas contributing to runoff (AA) will be utilised for rainwater harvesting (total assumed areas contributing to runoff 8 671 178 m²)
- Scenario 2 assumes that only a percentage of runoff (based on Table 5-22) can be captured (total assumed areas contributing to runoff 3 436 868 m²)

Table 5-21: Lephalale assumed developed area contributing to runoff

Zoning	Scenario 1	Scenario 2	
	Input roof Area (based on legal coverage)	Target Rainwater Harvesting Take up	Area contributing to runoff
Business 1	404 572	50%	202 286
Business 2	164 962	50%	82 481
Business 3	141 442	50%	70 721
Business 4	4 346	50%	2 173
Commercial	25 721	50%	12 861
Educational	709 577	100%	709 577
Government	32 221	100%	32 221
Industrial 1	137 044	50%	68 522
Industrial 2	157 408	50%	78 704
Institutional	131 222	100%	131 222
Municipal	185 206	100%	185 206
Residential 1	4 761 323	25%	1 190 331
Residential 2	496 421	25%	124 105
Residential 3	125 009	25%	31 252
Residential 4	328 584	25%	82 146
Special	866 119	50%	433 060
Total	8 671 178		3 436 868

Source: Own Construction (2018)

Due to a lack of information on roof type, a conservative 0.85 was selected for the runoff coefficient and 0.9 was selected as the filter efficiency.

Where: Scenario 1

$ADR = \text{Table 5-16}$

$AA = 8\,671\,178\text{ m}^2$

$C = 0.85$

$FE = 0.9$

$V = 2\,227\,513\text{ l}$

Where: Scenario 2

$ADR = \text{Table 5-16}$

$AA = 3\,436\,868\text{ m}^2$

$C = 0.85$

$FE = 0.9$

$V = 882\,887\text{ l}$

Based on the information generated as part of scenario 1, if all built-up areas in Ellisras have a building footprint equal to that as its prescribed zoning and every single drop of rainwater is harvested a total annual volume of 2 227 513 litres can be harvested. Although this sound impressive, compared existing consumption volumes which is equivalent to 7 509 711 882 litres annually, the volume of rainwater harvested will only be enough to substitute 0,029% of the existing annual municipal water demand.

Based on the information generated as part of scenario 2 (based on Table 5-22), if all built-up areas in Ellisras as a building footprint equal to that as its prescribed zoning but only a percentage (target rainwater harvesting take-up) is harvested a total volume of 882 887 litres can be harvested. Compared to existing consumption patterns, rainwater harvesting as per scenario 2 can only substitute 0,015% of the existing annual municipal water demand.

Table 5-22: Scenario 2 % Target Rainwater Harvesting by zoning

Scenario 2	% Target Rainwater Harvesting by zoning
Business 1	50%
Business 2	50%
Business 3	50%
Commercial	50%
Educational	100%
Government	100%
Industrial 1	50%
Industrial 2	50%
Institutional	100%
Municipal	100%
Residential 1	25%
Residential 2	25%
Residential 3	25%
Residential 4	25%
Special	50%

Source: Own Construction (2018)

Rainwater harvesting potential is also seasonal. Figure 5-21 shows that Ellisras has a seasonal high rainwater harvesting potential in January and February which is typical to that of South Africa summer rainfall season.

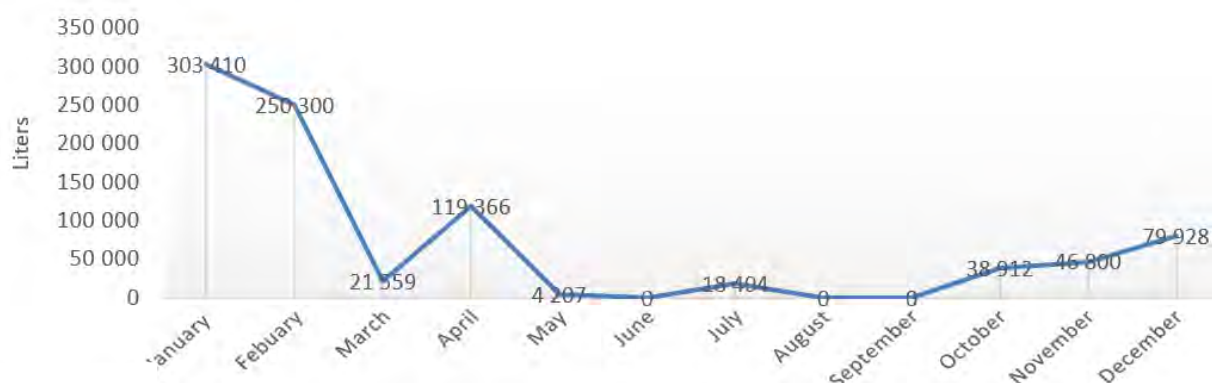


Figure 5-21: Ellisras seasonal rainwater harvesting potential

Source: Own Construction (2018) based on Weather SA daily rainfall data

Although Ellisras' rainwater harvesting potential is relatively low, the DWS states that "every drop count". In terms of Lephalale's existing SDF and land use scheme – no reference is made about the land use water quantity impact.

5.4.2.2.1.2 Mogalakwena Urban land use water quantity analysis

The land use water quantity analysis for Mogalakwena's formal built-up areas was calculated as an average annual consumption rate/volume. Mogalakwena Local Municipality uses Venus Financial System, Table 5-23 provides an extract of the "raw" state of billing information (note that it differs from that of Lephalale LM).

Table 5-23: Extract - Mogalakwena Local Municipality Venus Billing System Data

Unit	Account	YYYYMM	ReadDate	MeterReading	ReadType	MeterRef	MeterType
10000000000001000000000000	1031054	200505	20050505	1731.000	3	380147	MW08
10000000000001000000000000	1031054	200409	20040906	1692.000	3	380147	MW08
10000000000001000000000000	1031054	200410	20041012	1700.000	3	380147	MW08
10000000000001000000000000	1031054	200411	20041104	1703.000	3	380147	MW08

Source: Mogalakwena Local Municipality Venus Financial System (2016)

According to Mogalakwena Local Municipality's land use and billing information, of the 40 318 registered land parcels, the municipality should receive billing information for 93,99% of its formally registered urban erven. However, according to the Venus Financial System, only 11 854 erven is currently billed for water consumption.

This means that 68.72% of the municipality's formally registered erven remains unbilled. A matter of great concern is that 18 242 households (residential purposes) have no billing information, while the number of business that is not billed is more than those that are actually billed. This corresponds with the DWS statistics on non-revenue water for Mogalakwena Local Municipality which was calculated at 44% in 2011 (DWS, 2018).

In terms of billed consumed volume, Mogalakwena Local Municipality's average monthly billed consumption is calculated at 1 519 455 kl which equates to an estimated 131 kl per erf (Table 5-24). The spatial analysis revealed that more than 76.90% of water is consumed by residential stands. On average, a single house on a stand in Mogalakwena Local Municipality consumes 32.01 kl per month. Land used for Business, Industrial and Government purposes are the biggest water users per stand ranging between 1 200 and also 3 000 kl of water per stand. Table 5-24 summarises the average monthly land use water demand for Mogalakwena Local Municipality formally registered and billed land.

Table 5-24: Mogalakwena water consumption by land use

Land Use	Total monthly consumption	No of Properties	Kl/Erf
Educational Purposes	13 704	26	527
Government Purposes	2 365	7	338
Industrial Purposes	373 747	200	1 869
Institution Purposes	162	12	14
Municipal Purposes	15 572	12	1 298
Private Open Space	0	0	0
Public Garage	111	1	111
Public Open Space	469	2	235
Low density residential	342 453	10 695	32
Medium to high density residential	31 027	354	88
Business Purposes	739 777	285	2 596
Grand Total	1 519 455	11 595	131

Source: Own Construction (2018)

Figure 5-22 and Figure 5-23 reveals spatially Mogalakwena's land use water quantity impact. Figure 5-23 provides a 3D (three dimensional) view of the land use water quantity impact to better depict the multiple variables. Furthermore, the various colours represent land uses (e.g. yellow = residential; red = business, purple = industrial) whereas the height of the "skyscraper" represents the average monthly water consumption of the specific property.

Unlike Lephalale, Mogalakwena's land use water quantity impact is concentrated in two prominent areas, the CBD and the Industrial zone. The water demand in Mogalakwena's residential areas is relatively low ranging between 0 and 100 kl per month.

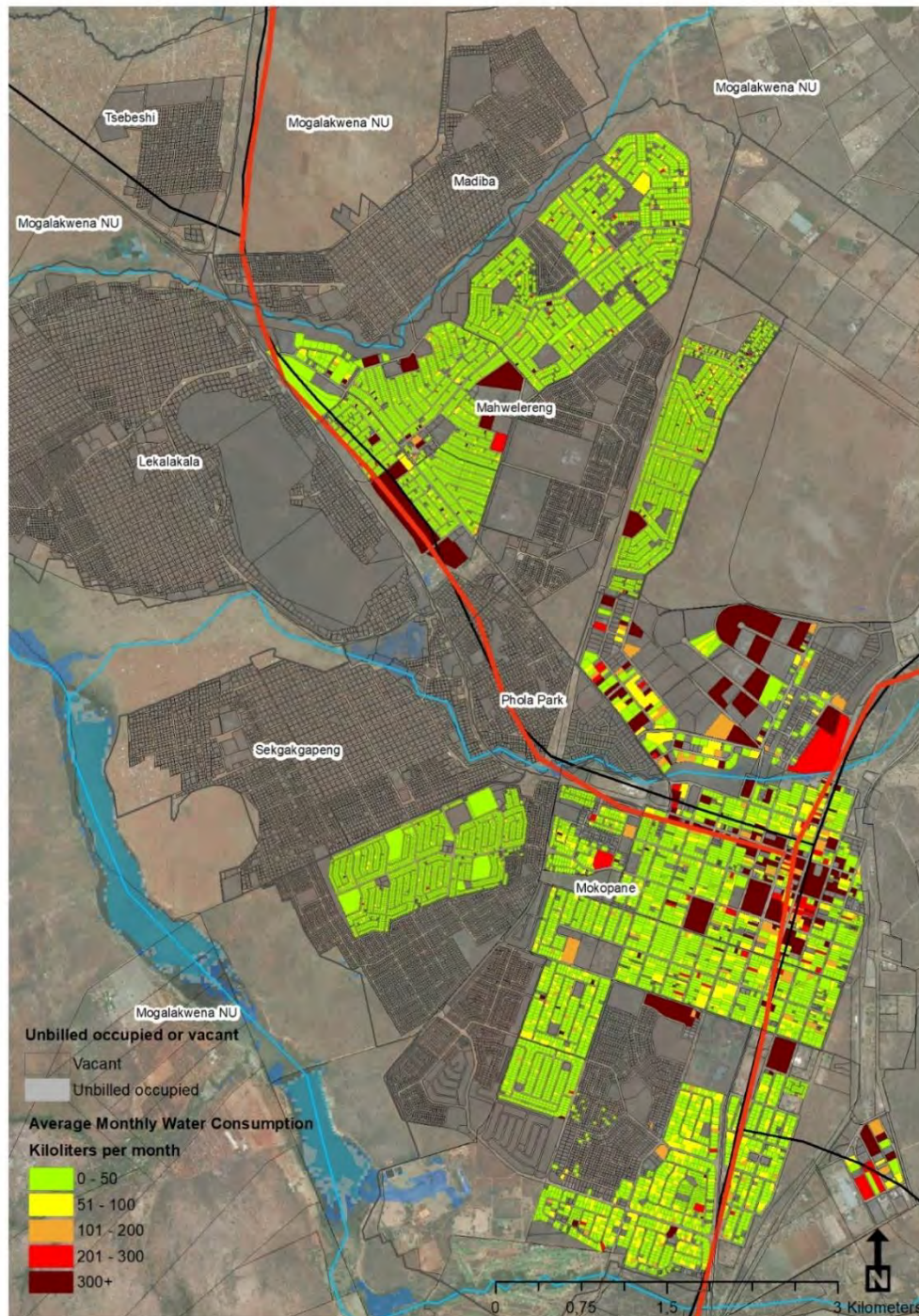


Figure 5-22: Mogalakwena Local Municipality monthly water consumption

Source: Own Construction (2018)

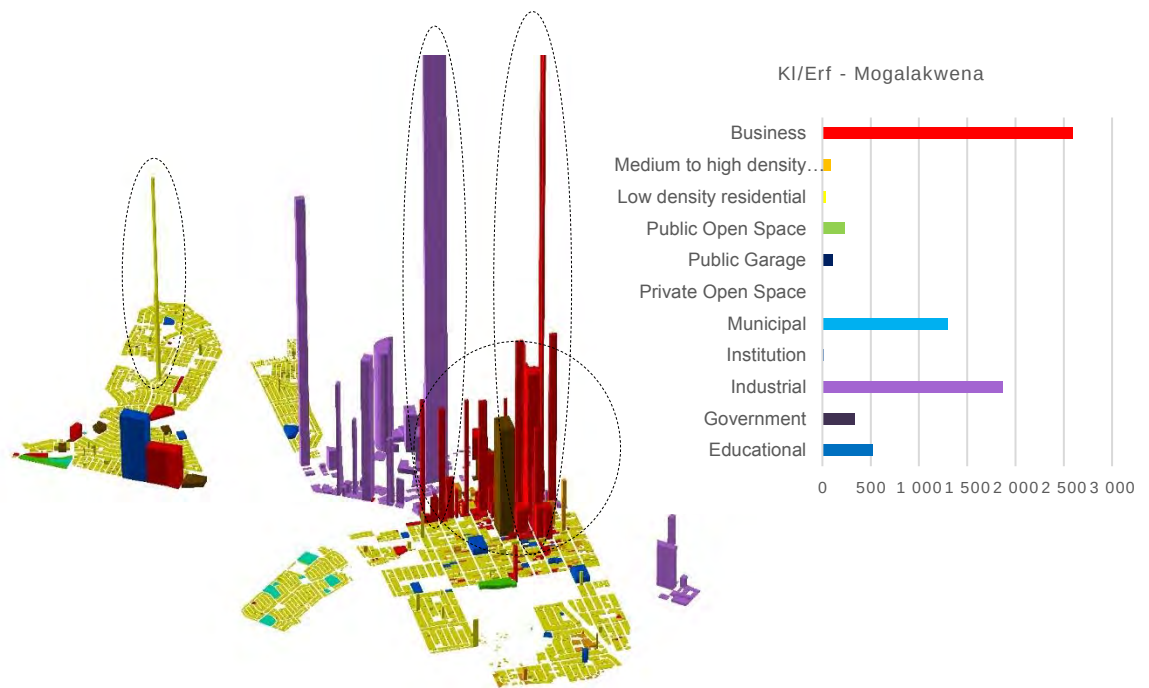


Figure 5-23: 3D Mogalakwena monthly water consumption per land use

Source: Own Construction (2018)

From the above spatial analysis, it once again becomes clear that certain individual land uses have irregular high-water demand. This too can be the result of incorrect billing information, leaking pipes or illegal land use.

Based on the information derived from the land use water consumption model, Figure 5-24 identified several zones where WCWDM should be priorities. In Mogalakwena, the WCWDM zone covers 259 erven, a small 2% of the municipality's formally register and billed erven. Most of the selected erven (not all) have an average monthly water consumption of more than +301 kl which amount to a total monthly volume of 1 053 671 kl the equivalent to 69% of Mogalakwena's total monthly water consumption. Once again, with the NDP's target in mind, the WCWDM zone as illustrated in Figure 5-20 can facilitate the municipality to achieve this target by proposing the following:

- All land uses (only 259 erven) affected by the WCWDM zone MUST reduce their monthly water demand by only 20% and all other land use should reduce their demand by 2%.
 - o Table 5-25 explains that if all 259 erven (currently identified as having an irregular high-water demand) reduce their monthly water demand by 20%, monthly water savings of 210 734 kl (14% of the existing consumed volume) can be achieved.
 - o In addition, the remaining 11 336 land use should reduce their monthly water demand by 2%. This will amount to an additional water savings of 9 316 kl (also calculated as

only 1 kl per erf per month). All in all, a total monthly water savings of 220 050 kl can be achieved. In terms of the NDP's target –Mogalakwena can reach a 15% target for reduction in water consumption (below business as usual). This can be achieved by implementing:

- good housing;
- retrofitting old faucets with water-saving faucet (immediate saving of up to 25%);
- onsite greywater reuse;
- water harvesting;
- the municipality can charge more for water if they use more than which is considered appropriate (Flexi tariff); or
- the municipality can implement a trickle flow strategy.
- reducing stand size; increasing densities.

Table 5-25: Spatial targeted strategy to reduce water demand

Spatial areas	Total monthly consumption (kl)	WCDM target	Potential savings (kl)
Sum of total water demand in WCDM zone (kl)	1 053 671	20%	210 734
Sum of total water demand in Mogalakwena (kl) excluding demand in WCDM zone	465 784	2%	9 316
Sum of total water demand in Mogalakwena (kl)	1 519 455		
NDP target 15%			220 050

Source: Own Construction (2018)

Furthermore, the spatial data also indicates that 5 Government and 4 Municipal land use are located in the WCWDM zone. The buildings should be flagged for immediate intervention. In terms of Mogalakwena's existing SDF and land use scheme clause – absolutely no reference is made about the land use water quantity impact.

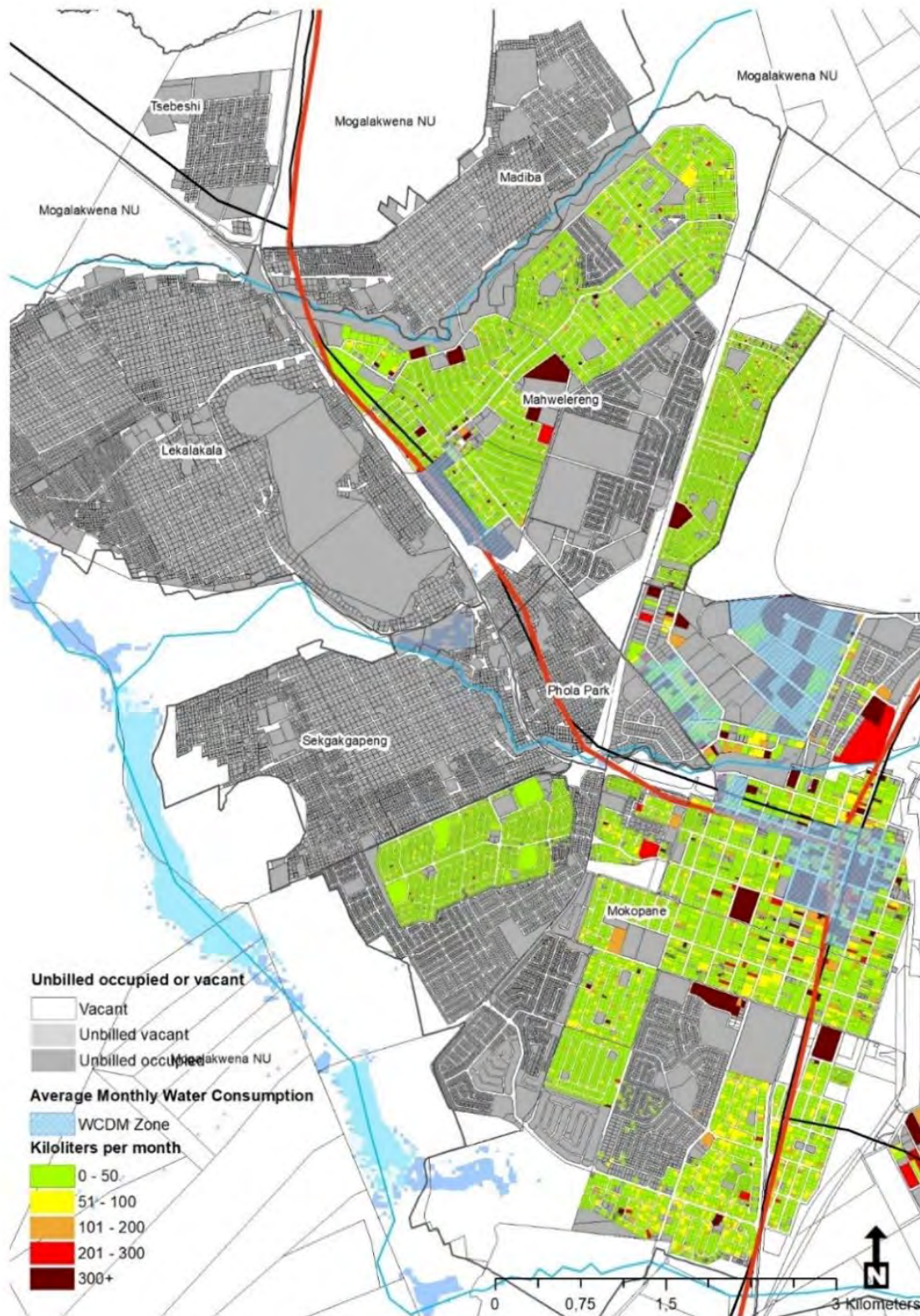


Figure 5-24: Mogalakwena WCDM Intervention Zone

Source: Own Construction (2018)

Adopting the proposed methodology to determine the rainwater harvesting potential for Mokopane node the following findings were made. Mogalakwena Local municipality's daily rainfall information was obtained from the SA Weather services (see Annexure F). According to the daily rainfall data, Mokopane received 438.6 mm of rain for the entire year. The analysis assumed that each property in Mokopane as a building footprint equal to that of its legal coverage (e.g. 60% of a residential stand is covered by a roof). Using the zoning information and size of each land parcels the "assumed" areas contributing to runoff (AA) was calculated in GIS. Two scenarios were created:

- Scenario 1 assumes that the total assumed areas contributing to runoff (AA) will be utilised for rainwater harvesting (total assumed areas contributing to runoff 36 041 244 m²)
- Scenario 2 assumes that only a percentage of runoff (Table 5-22 in Section 5.4.2.2.1.1) can be captured (total assumed areas contributing to runoff 12 352 944 m²)

Table 5-26: Mogalakwena assumed developed area contributing to runoff

Zoning	Scenario 1	Scenario 2	
	Input roof Area (based on legal coverage)	Target Rainwater Harvesting Take up	Area contributing to runoff
Business 1	1 357 950	50%	678 975
Business 2	50 944	50%	25 472
Business 3	17 936	50%	8 968
Business 4	67 772	50%	33 886
Commercial	7 037	50%	3 518
Educational	1 877 450	100%	1 877 450
Government	650 790	100%	650 790
Industrial 1	347 536	50%	173 768
Industrial 2	1 389 747	50%	694 873
Industrial 3	126 751	50%	63 375
Institutional	741 422	100%	741 422
Residential 1	28 695 268	25%	7 173 817
Residential 2	148 334	25%	37 084
Residential 3	350 390	25%	87 598
Residential 4	16 044	25%	4 011
Special	36 041 244		12 352 944

Source: Own Construction (2018)

Due to a lack of information on roof type, a conservative 0.85 was selected for the runoff coefficient and 0.9 was selected as the filter efficiency.

Where: Scenario 1

$ADR = \text{Table 5-21}$

$AA = 36\,041\,244\text{ m}^2$

$C = 0.85$

$FE = 0.9$

$V = 12\,092\,883\text{ l}$

Where: Scenario 2

$ADR = \text{Table 5-21}$

$AA = 12\,352\,944\text{ m}^2$

$C = 0.85$

$FE = 0.9$

$V = 4\,144\,771\text{ l}$

Based on the information generated as part of scenario 1, if all built-up areas in Mokopane have a building footprint equal to that as its prescribed zoning and every single drop of rainwater is harvested a total annual volume of 12 092 883 litres can be harvested. Although this sound impressive, compared existing consumption volumes which is equivalent to 2 065 274 000 litres annually, the volume of rainwater harvested will only be enough to substitute 0,048% of the existing annual municipal water demand.

Based on the information generated as part of scenario 2, if all built-up areas in Mokopane as a building footprint equal to that as its prescribed zoning but only a percentage (Table 5-22 in Section 5.4.2.2.1.1) is harvested a total volume of 4 144 771 litres can be harvested. Compared to existing consumption patterns, rainwater harvesting as per scenario 2 can only substitute 0,016% of the existing annual municipal water demand. Figure 5-25 shows that Mokopane has a seasonal high rainwater harvesting potential in January and February which is typical to that of South Africa summer rainfall season.



Figure 5-25: Mokopane seasonal rainwater harvesting potential

Source: Own Construction (2018) based on Weather SA daily rainfall data

Rainwater harvesting is an alternative source of water, and even though limited throughout the year, in the long run, this alternative source can make a substantial difference in local

communities. Mogalakwena's existing SDF and land use scheme makes no reference its land use water quantity impact.

5.4.2.2.1.3 Land use water quantity analysis: Key Findings and conclusion

The evidence based land use water quality analysis conducted for both Lephalale and Mogalakwena local municipality proves that all land use has a water quantity impact. However, what became evident is that, one cannot assume that a specific land uses for e.g. business will have a higher water demand than that of residential land use. It can also not be assumed that certain geographic areas will have a higher water demand than others, although in Mogalakwena's case the water demand was highly concentrated in the CBD.

Other key findings, related to spatial planning and land use management and land use water demand includes:

- Lephalale Local Municipality consists of 2 000 fewer properties than Mogalakwena. Yet Lephalale consumes 1.8 times more water every month than Mogalakwena.
- One explanation for the high-water usage in Lephalale could, in fact, be related to the generally low cost of water as well as economic activities compared to Mogalakwena. Figure 5-26 shows the cost of water per kl. The cost for water once consumption is between 6-20 kl differs with 8.26 R/kl, as Lephalale only charges 5.95 R/kl and Mogalakwena 14.18 R/kl. The biggest tariff difference is seen when more than 60 kl is used. Mogalakwena charges 28.86 R/kl where Lephalale only charges 10.51 R/kl which is, in fact, lower than all of Mogalakwena water consumption tariffs.

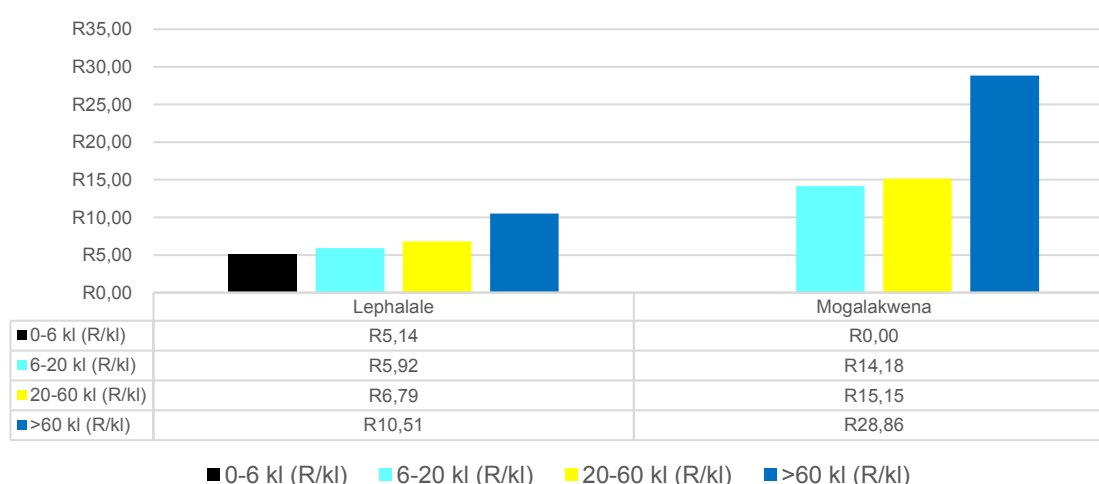


Figure 5-26: Municipal Tariffs 2015 Lephalale vs. Mogalakwena

Source: Own Construction (2018) adopted from DWS (2018)

- The major water users in Mogalakwena Local Municipality includes industrial (24.6%) and business stands (48.7%). In Lephalale Local Municipality, more than 88% of water is consumed by single residential stands. However, the land audit data pointed out that Mogalakwena Local Municipality has 200 more established industrial stands than Lephalale Local Municipality which only has 32 industrial stands (see Figure 5-27).

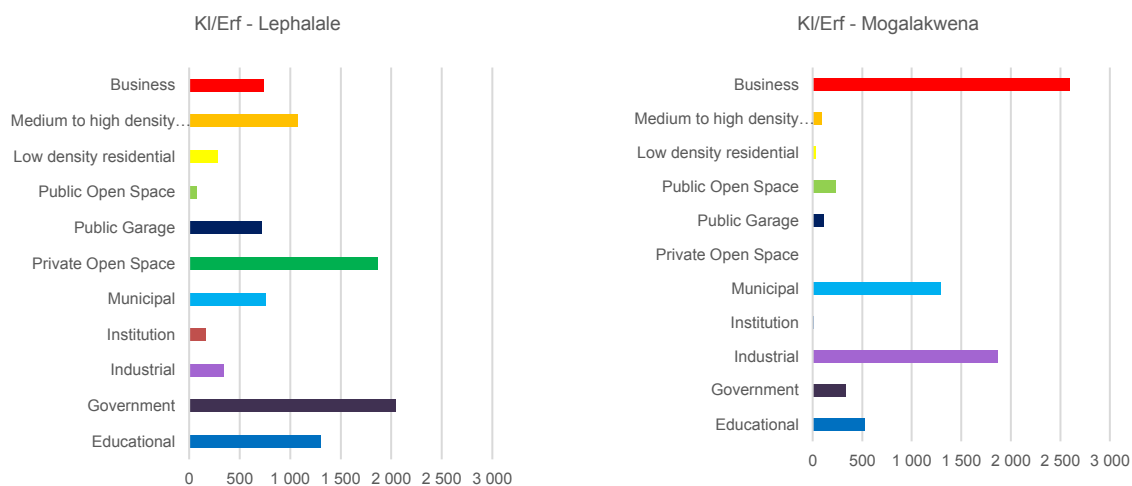


Figure 5-27: Water consumption by land use

Source: Own Construction (2018)

- The biggest water users per stand in Mogalakwena remains the business and industrial uses, using between 1 800 and 2 600 kilolitres of water per month per stand. In Lephalale, private open space (the golf course) and Government uses are the biggest water users per stand ranging between 1 800 and 2 000 kilolitres of water per stand.
- The most surprising finding in comparing water use per land use between the two municipalities is the fact that low-density residential stands in Lephalale consume 7 times more water than those of Mogalakwena. On average a single house on a stand in Lephalale consumes 275 kl of water. The corresponding figure for Mogalakwena is 32 kl. The average stand sizes for these two land uses do not differ dramatically, in fact, the average residential stand in Lephalale is smaller (680 m²) than that of Mogalakwena (741 m²). Five aspects that may (in part) be able to explain the massive variance in consumption are:
 - On average, residential properties in Lephalale are occupied by households with a higher income (R 169 500/household/month) than Mogalakwena (R 84 347/household/month).

- o Lephalale is slightly warmer than Mogalakwena.
- o Water is significantly “cheaper” in Lephalale compared to Mogalakwena (refer to earlier sections in the report).
- o It may be possible that water metres in the areas are faulty and therefore reporting inaccurate data.
- o The data from the billing system could be wrong.

From the above, it becomes relatively clear that both land use and its spatial location should be targeted for Water Conservation and Water Demand Management strategies:

- In Lephalale’s case, the municipality can almost achieve the NDP target to reduce urban water demand by 15% by targeting 716 erven to implement WCWDM tactic. Lephalale will also require all other properties to reduce their water demand by 14% below business as usual.
- In Mogalakwena’s case, only 259 properties will be required to reduce their water demand by 20% while the remaining erven will need to adjust to a small 2% reduction in monthly usage.
- Furthermore, municipal-owned buildings or land uses with high water consumption patterns must be flagged for immediate interventions as it is the municipalities objective to become more water sensitive.
- The potential for rainwater harvesting is limited in both municipalities. However, the following should be kept in mind:
 - With minimal treatment, rainwater could be used to supplement the potable water supply for secondary water uses such as toilet flushing and garden irrigation. However, South Africa is still lacking a regulatory framework for the different categories of rainwater use i.e. drinking water for potable use (humans and livestock); irrigations and gardening; commercial use and industry.
 - Government, municipal, educational, institutional and health care facilities require relatively large erven as buildings are designed to accommodate large groups of people for several hours. The size of the building is favourable for water harvesting and storing. Stormwater from parking areas should also be harvested and used to water sports field and to clean premises. The same goes for community facilities with large gardens. Harvested water can also be used to flush toilets.
 - Beatification of business and industrial zones through WSUD and other green design elements encourages investment potential and a sense of places. Water demand by

these land uses are also relatively high and water efficient appliances, practices and initiatives should be the main priority for all business and industrial land uses.

The land use water quantity analysis can help urban planners to build an understanding of existing water demand based on land use which can also translate into future demand for water. It should, therefore, be used to guide or influence land use approvals or rejections while targeted water conservation and demand management strategies should be implemented through development controls or incentives. See further recommendations on how this analysis can inform municipal planning tools to achieve WSS as provided in Chapter 7.

5.4.2.2.2 Land use water quality impact

The quantitative impact of land uses on water resources refers to the level of pollution (or threat rating) caused by such land use. This analysis focuses specifically on the qualitative impact of land use on stormwater. Macfarlane *et al.*, (2014:29-34) developed a generic threat table for land use activities both within the construction and operational phases, grouped into uniform classes based on the primary threat type identified. Macfarlane *et al.*, (2014:31) assessed the threats posed by land use activities associated with each sub-sector based on the following aspects:

- sedimentation and turbidity;
- increased inputs of nutrients;
- increased toxic contaminants;
- concentration of salts (salinization); and,
- pathogens (i.e. disease-causing organisms).

Threat ratings must, however, be reviewed by an aquatic specialist as this provides only a general overview of potential threats.

Table 5-27: Threat rating

Threat rating	symbol	Threat score	Description
Very Low	VL	0.2	The level of threat (based on likelihood, magnitude and frequency of potential impacts) posed by the land use / activity to water resources is very low for the threat type assessed. In the case of water quality impacts, SLV limits are unlikely to be exceeded in diffuse surface runoff.
Low	L	0.4	The level of threat posed by the land use / activity to water resources is low for the threat type assessed. In the case of water quality impacts, GLV limits are unlikely to be exceeded in diffuse surface runoff.
Moderate	M	0.6	The level of threat posed by the land use / activity to water resources is moderate for the threat type assessed. If not managed, pollutant loads in diffuse surface runoff may range up to 5x the GLV limit.
High	H	0.8	The level of threat posed by the land use / activity to water resources is high for the threat type assessed. If not managed, pollutant loads in diffuse surface runoff may range up to 10x the GLV limit.
Very High	VH	1	The level of threat posed by the land use / activity to water resources is very high for the threat type assessed. If not managed, pollutants load in diffuse surface runoff may exceed 10x the GLV limit.

Source: Macfarlane *et al.* (2014:31) See Annexure G for the detailed threat rating scores.

With this information, the water quality impact by land use can be determined. The purpose of this analysis is to identify areas where land use is causing high level of stormwater pollution. Table 5-28 provide the evidence based methodology for conducting a land use water quality impact assessment.

Table 5-28: Land use water quality assessment methodology

Map	Determine the spatial location and extent of... Method / Steps
Land use water quality impact	
All basemap data - A01 ; A02; A03; A04; A05; A06; A07; A08; A09; A10; A11; A12; A13; and A14 Infrastructure data - A20; A21; A22; A23; A24; A25; A26; A27; and A28 Land use data - As per settlement scale land audit. Generic threats table - As per Macfarlane <i>et al.</i> (2014:31)	...the land use water quality impact - Macfarlane <i>et al.</i> (2014) developed a generic threat table for land use activities both within the construction and operational phases, grouped into uniform classes based on the primary threat type identified. The generic threats ratings have 82 detailed land uses, grouped into 9 main sectors which includes Agriculture, Industry; Mixed-use/Commercial/Retail/Business; Civic and Social; Residential; Open space; Transportation infrastructure; Service infrastructure and Mining. A realistic “worst-case” scenario is provided for each sector. - For mapping purposes, the 82 detailed land uses were reduced to match the current existing land uses as per the spatial data. - Once the treat ratings have been reclassified, use the “Join and Relate” function in GIS to linking the “land use description” to the “generic threat score”. The land use threat rating considers the following: - sedimentation and turbidity - increased inputs of nutrients - increased toxic contaminants

	• concentration of salts (salinization) • pathogens (i.e. disease-causing organisms) 4. Use the “Symbology” – “Quantities” – “Gradated Colour” and select the “Threats rating” and method “Equal Interval” (5 Classes) to differentiate between the land use water quality threats rating (See Annexure 5.10 Land use water quality threat rating for the detailed threat rating scores): • 0.2 very low threat rating • 0.4 Low threat rating • 0.6 Moderate threat rating • 0.8 High threat rating • 1 Very High threat rating 5. Identify areas with high threat ratings and create a new shapefile representing "Water quality intervention zone".
Blue green corridor	
Waterberg Bioregional Plan • Untouched CBA ESA network National Freshwater Ecosystem Protection Areas • FEPA Buffer zone Land use data • Vacant land • Public Open space • Private Open space • Recreational purposes (e.g. Golf Course)	...areas to be used as part of the SuDS treatment train 6. Use the “Merge” to in GIS to merge all the mapped shapefiles. 7. Once merged, export the new shapefile and label it Blue-green corridor.
Final Map	
Create several individual maps • sedimentation and turbidity threat • increased inputs of nutrients • increased toxic contaminants • concentration of salts • pathogens	8. For reporting purposes, create two scenarios' • Scenario 1: threat rating of exiting land use • Scenario 2: threat rating of all land use once developed based on proposed zoning information. • Visually inspect the results.
Create a final map: • Water quality intervention zone • Blue green corridor	9. Add the spatial data "Blue-green corridor development zone" (Step 38) as an overlay to the areas of " Water quality intervention zone and identify spatial areas to form part of the SuDS treatment train which will help to treat polluted stormwater before it enters the natural environment.

Source: Own construction (2018) see Annexure E for data source list

Section 5.4.2.2.2.1 and Section 5.4.2.2.2.2 to follow summarises and spatialise the key findings of the land use water quality analysis conducted for Lephalale and Mogalakwena Local Municipality. Section 5.4.2.2.2.3 reflects on the key findings and draws a conclusion.

5.4.2.2.2.1 Lephalale land use water quality analysis

Lephalale's land use water quality impact was determined by mean of Macfarlane *et al.* (2014) generic threats rating as well as the spatial data collected as part of the land audit process.

As noted in Table 5-28, a land use reclassification process was required to match the land uses to the generic threats rating table (see Annexure G). For this reason, the most detailed level of land use information, as well as zoning information was used to identify the most accurate threats rating per land use. It should therefore also be noted that the land use information presented in this section will differ slightly from the previous sections as the previous sections grouped land uses while this section dismantles the groupings in order to find the most detailed description of land use. The following section provides the findings of the land use water quality analysis in the following order:

- sedimentation and turbidity
- increased inputs of nutrients
- increased toxic contaminants
- concentration of salts (salinization)
- pathogens (i.e. disease-causing organisms)

Table 5-29 provides a summary of Lephalale's land use water quality impact.

Table 5-29: Lephalale land use water quality threats rating

Sedimentation and turbidity					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use sedimentation and turbidity threats rating	90.9%	6.0%	0.9%	1.5%	0.7%
% of future land use sedimentation and turbidity threats rating	95.1%	3.2%	0.5%	0.6%	0,6%
Increased inputs of nutrients					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use nutrients threats rating threats rating	91.1%	5.3%	2.7%	0.7%	0.1%
% of future land use nutrients threats rating threats rating	94.2%	2.9%	2.2%	0.6%	0.1%
Increased toxic contaminants					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Increased toxic contaminants threats rating	91.0%	4.8%	3.3%	0.1%	0.8%
% of future land use Increased toxic contaminants threats rating	94.2%	2.3%	2.9%	0.0%	0.6%
Salinization					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Salinization threats rating	95.5%	3.6%	0.0%	0.8%	0.0%
% of future land use Salinization threats rating	96.7%	2.7%	0.0%	0.7%	0.0%
Pathogens					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Pathogens threats rating	2.0%	96.2%	0.9%	0.7%	0.2%
% of future land use Pathogens threats rating	1.8%	97.0%	0.5%	0.6%	0.1%

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Sedimentation and turbidity - According to the land use water quality impact spatial data, 2.2% of all urban land use has a high to very high sedimentation and turbidity threat rating. In future, land uses with a low sedimentation and turbidity threat rating will increase by 4.2% while the percentage of total land uses with a high and very high threat rating will decrease to 0,6% each. According to the spatial data industrial; residential informal; and filling station has the highest sedimentation and turbidity threats rating (see Figure 5-28).

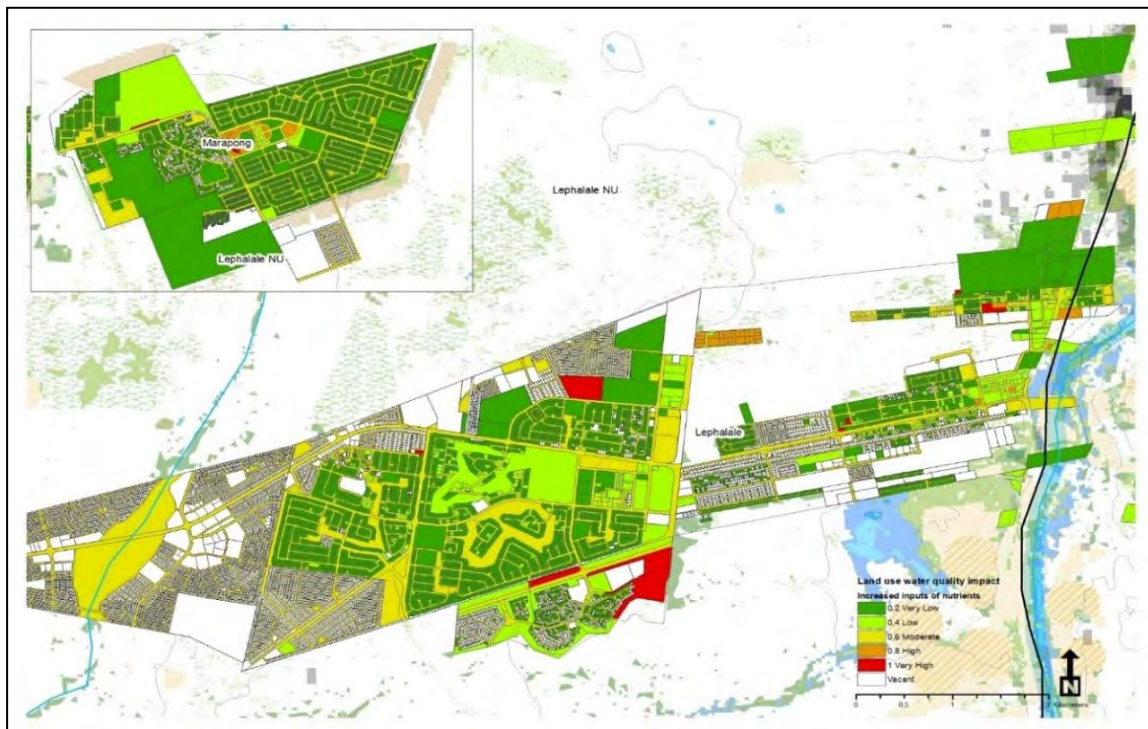


Figure 5-28: Lephalale's existing land use nutrients threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Increased inputs of nutrients - According to the land use water quality impact spatial data, 0.9% of all urban land use has a high to very high nutrients input threat rating. In future, land uses with a low nutrients threat rating will increase by 3.1% while land use with very high threat ratings is likely to decrease. According to the spatial data public service industries, industrial; residential informal has the highest risk of causing increased nutrients in stormwater resources (see Figure 5-29).

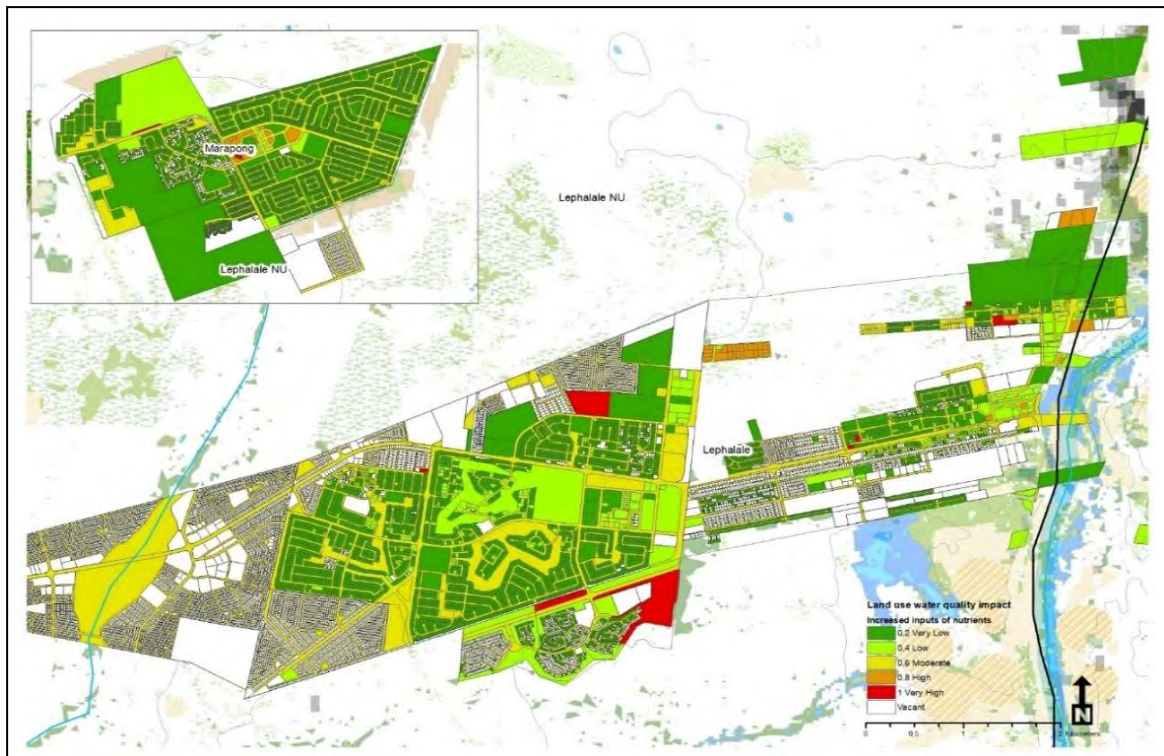


Figure 5-29: Lephalale's existing land use nutrients threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Increased toxic contaminants - According to the land use water quality impact spatial data, 0.9% of all urban land use has a high to very high toxic contamination threat rating. In future, land uses with a low threat rating will increase by 3.2% which is not a concern. While moderate, high and very high threat ratings are likely to decrease. The above information is illustrated spatially in Figure 5-30. According to the spatial data, Business land uses in Lephalale Local Municipality is most likely to cause toxic contamination of stormwater resources.

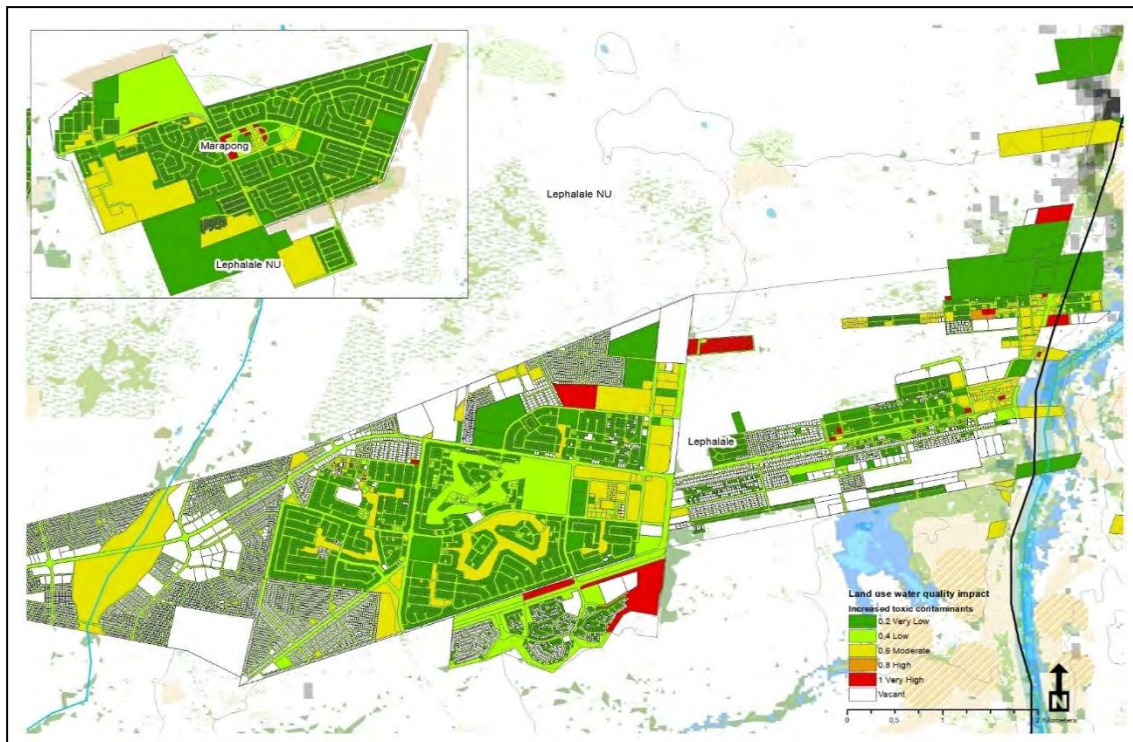


Figure 5-30: Lephalale's existing land use toxic contaminants threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

The concentration of salts (salinization) - According to the land use water quality impact spatial data, 0.8% of all urban land use has a very high salinization threat rating. In future, water resources salinization threats will remain low as the overall percentage increase to 96,7% and all other threat ratings will decrease. According to the spatial data, industrial, residential informal and public service industries has the highest risk of causing increased salinization in stormwater resources (see Figure 5-31).

Pathogens (i.e. disease-causing organisms) - According to the land use water quality impact spatial data, 1.1% of all urban land use has high levels of pathogens threat rating. In future, the percentage of land use with a low threat rating will increase from 96.2% to 97.0%. The percentage of land use with a moderate to very high pathogen threat rating will most likely decrease. According to the spatial data public service industries, industrial; residential informal has the highest risk of causing increased nutrients in stormwater resources (see Figure 5-32).

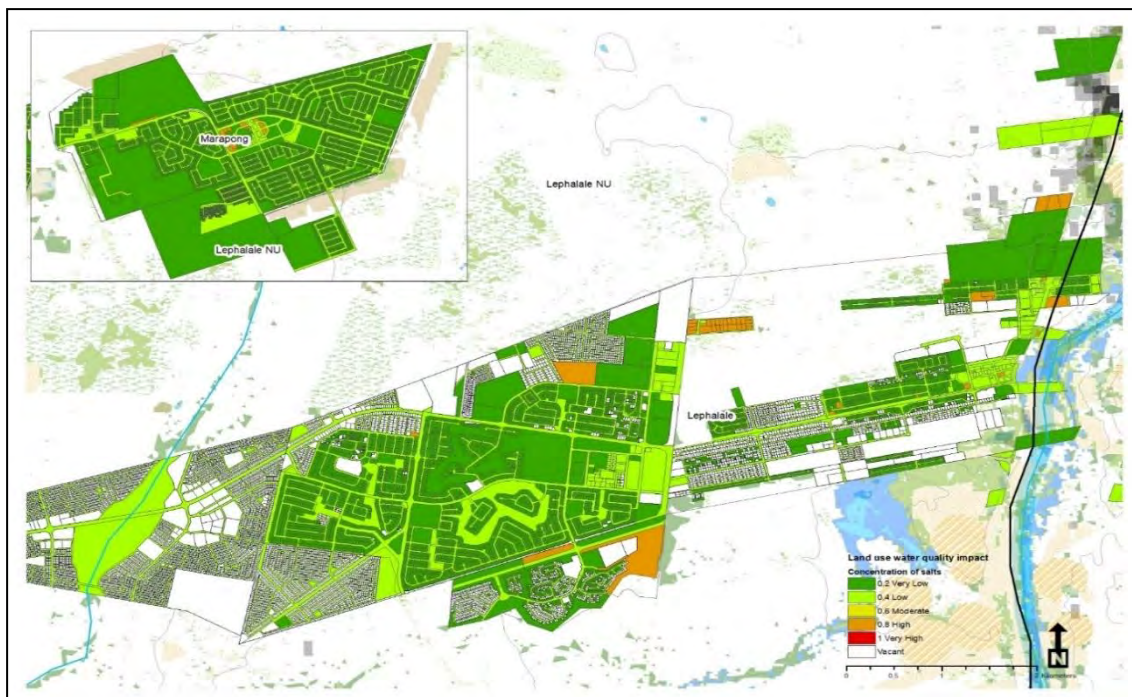


Figure 5-31: Lephalale's existing land use concentration of salts threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

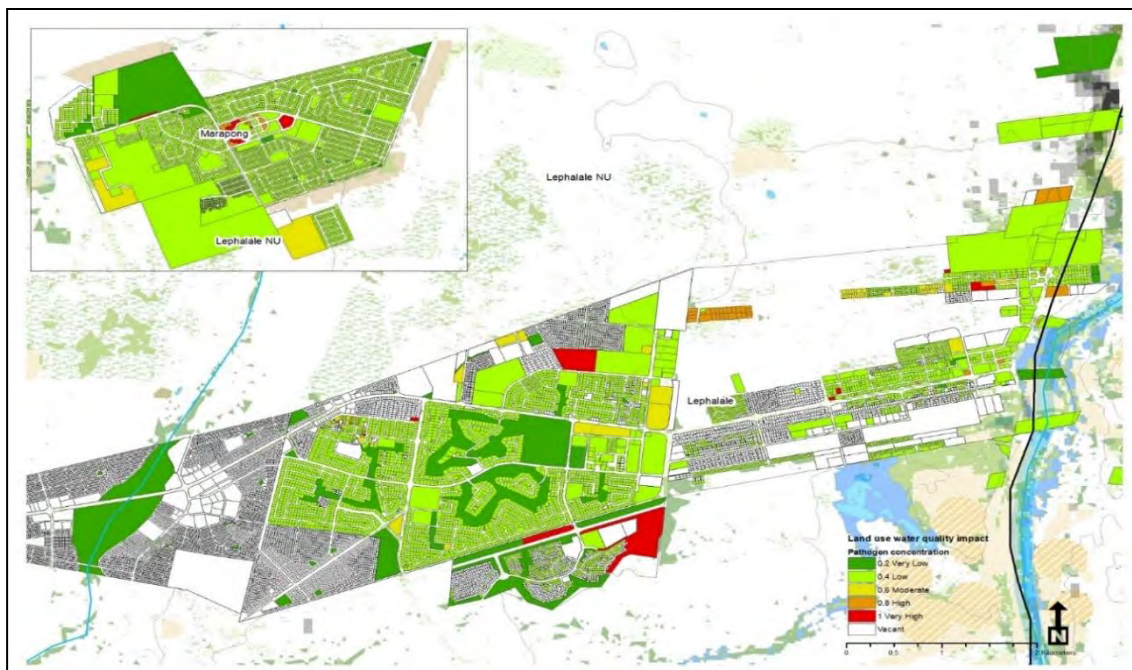


Figure 5-32: Lephalale's existing land use pathogen threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Unlike the Land Use Water Quantity analysis, where no true trend in terms of high consumption was found, this analysis clearly indicates that Public Service Industries, Industrial and Residential Informal land uses has the highest threat rating throughout. By consolidating all land uses with threat rating higher than 0,8 the municipality can target specific areas where the implementation of SuSD should become the main priority. These areas for Ellisras have been identified in Figure 5-33.

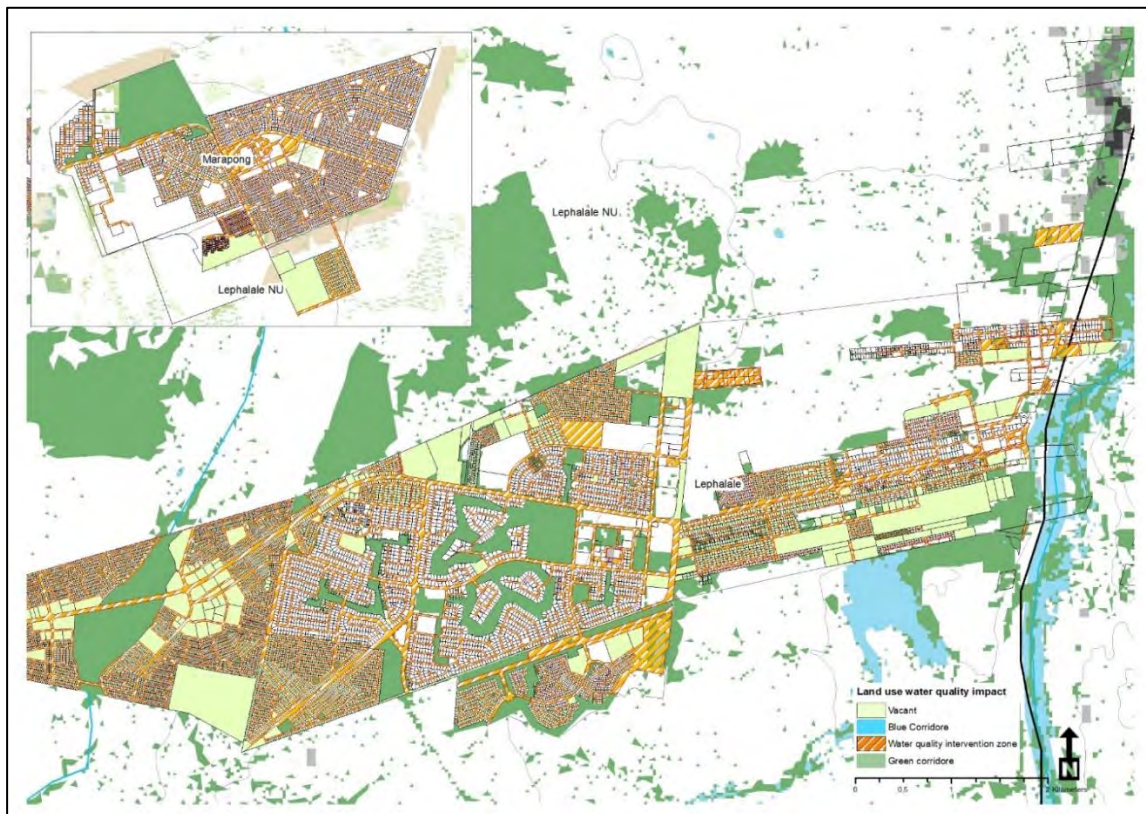


Figure 5-33: Lephalele's Land Use Water Quality Intervention Zone

Source: Own Construction (2018)

Lephalele Local Municipalities existing SDF and LUS makes no mentioning of its land use water quality impact nor does it address any other matter related to water quality.

5.4.2.2.2 Mogalakwena land use water quality analysis

The following section provides the findings of Mogalakwena Local Municipality (Mokopane specifically) land use water quality analysis in the following order:

- sedimentation and turbidity
- increased inputs of nutrients
- increased toxic contaminants
- the concentration of salts (salinization)

- pathogens (i.e. disease-causing organisms)

Table 5-30 provides a summary of Mokopane's land use water quality impact.

Table 5-30: Mogalakwena's land use water quality threats rating

Sedimentation and turbidity					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Sedimentation and turbidity threats rating	94.3%	3.4%	1.3%	0.1%	0.9%
% of future land use Sedimentation and turbidity threats rating	94.6%	3.1%	1.1%	0.1%	1.2%
Increased inputs of nutrients					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use nutrients threats rating threats rating	94.4%	2.8%	1.7%	0.9%	0.2%
% of future land use nutrients threats rating threats rating	94.2%	2.9%	2.2%	0.6%	0.1%
Increased toxic contaminants					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Increased toxic contaminants threats rating	94.4%	0.1%	4.4%	0.1%	1.0%
% of future land use Increased toxic contaminants threats rating	91.7%	0.1%	6.9%	0.1%	1.3%
Salinization					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Salinization threats rating	95.3%	2.5%	1.0%	1.1%	0.0%
% of future land use Salinization threats rating	92.7%	5.2%	0.8%	1.3%	0.0%
Pathogens					
Generic threats rating	0,2	0,4	0,6	0,8	1
% of existing land use Pathogens threats rating	0.4%	97.2%	1.3%	0.9%	0.2%
% of future land use Pathogens threats rating	3.3%	94.3%	1.1%	1.2%	0.2%

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Sedimentation and turbidity - According to the land use water quality impact spatial data, 1% of all urban land use has a high to very high sedimentation and turbidity threat rating. In future, land uses with a very low threat rating will increase by 0.3% and land use with a low threat rating will decrease with 0.3%. Of great concern to the municipality is that the percentage of land use with very high sediment and turbidity threat rating will most likely increase from 0.9% to 1.2%. According to the spatial data Industrial 1 and 2; mining, residential and public service infrastructure has the highest sedimentation and turbidity threats rating. The above information is illustrated spatially in Figure 5-34.

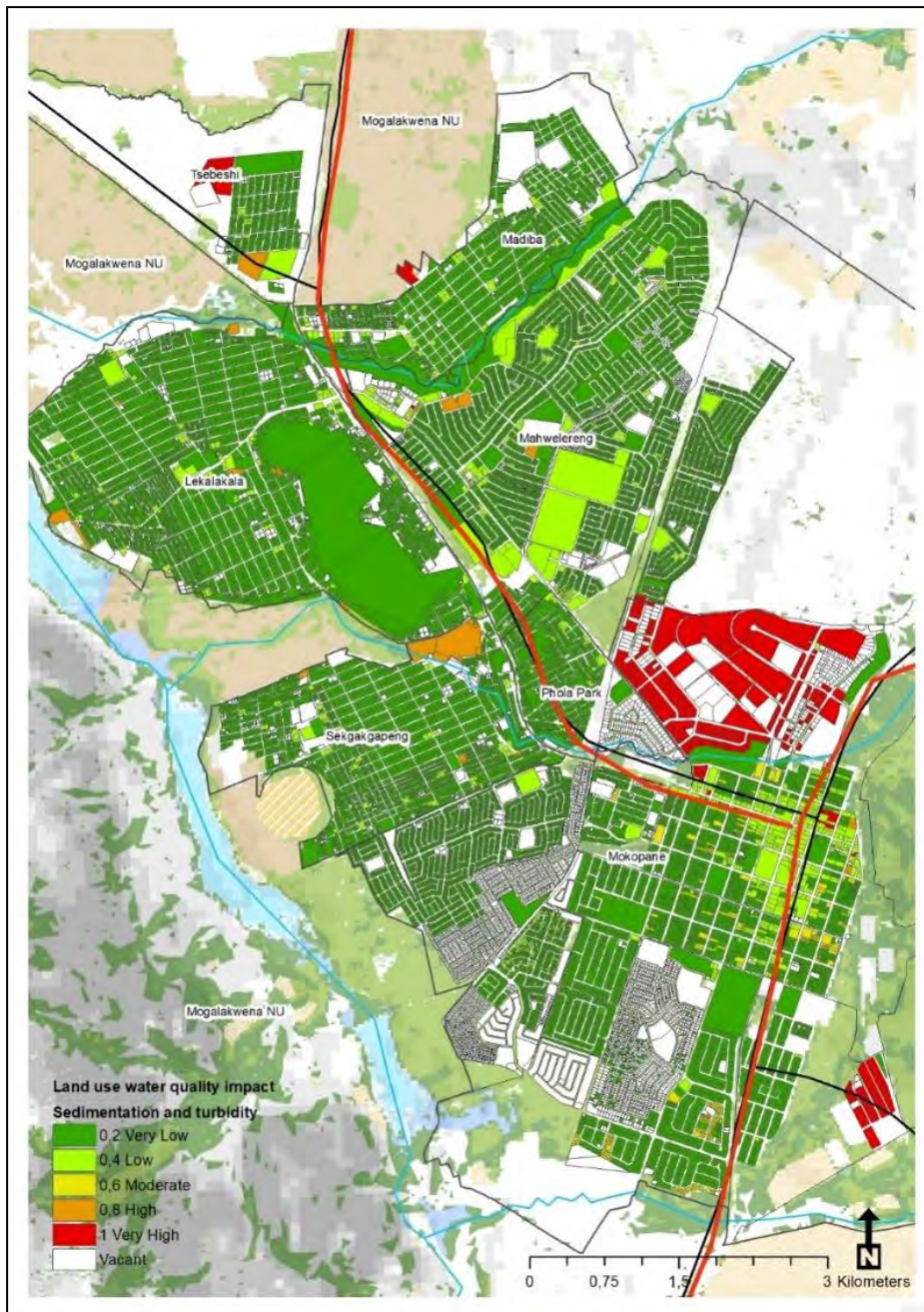


Figure 5-34: Mogalakwena existing land use sedimentation & turbidity threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Increased inputs of nutrients - According to the land use water quality impact spatial data, 1.1% of all urban land use has a high to very high nutrients threat rating. In future, the percentage of land use with a high and very high threat rating will both decrease. According to the spatial data public service industries, residential, and industrial land uses has the highest risk of causing increased nutrients in stormwater resources. The above information is illustrated spatially Figure 5-35.

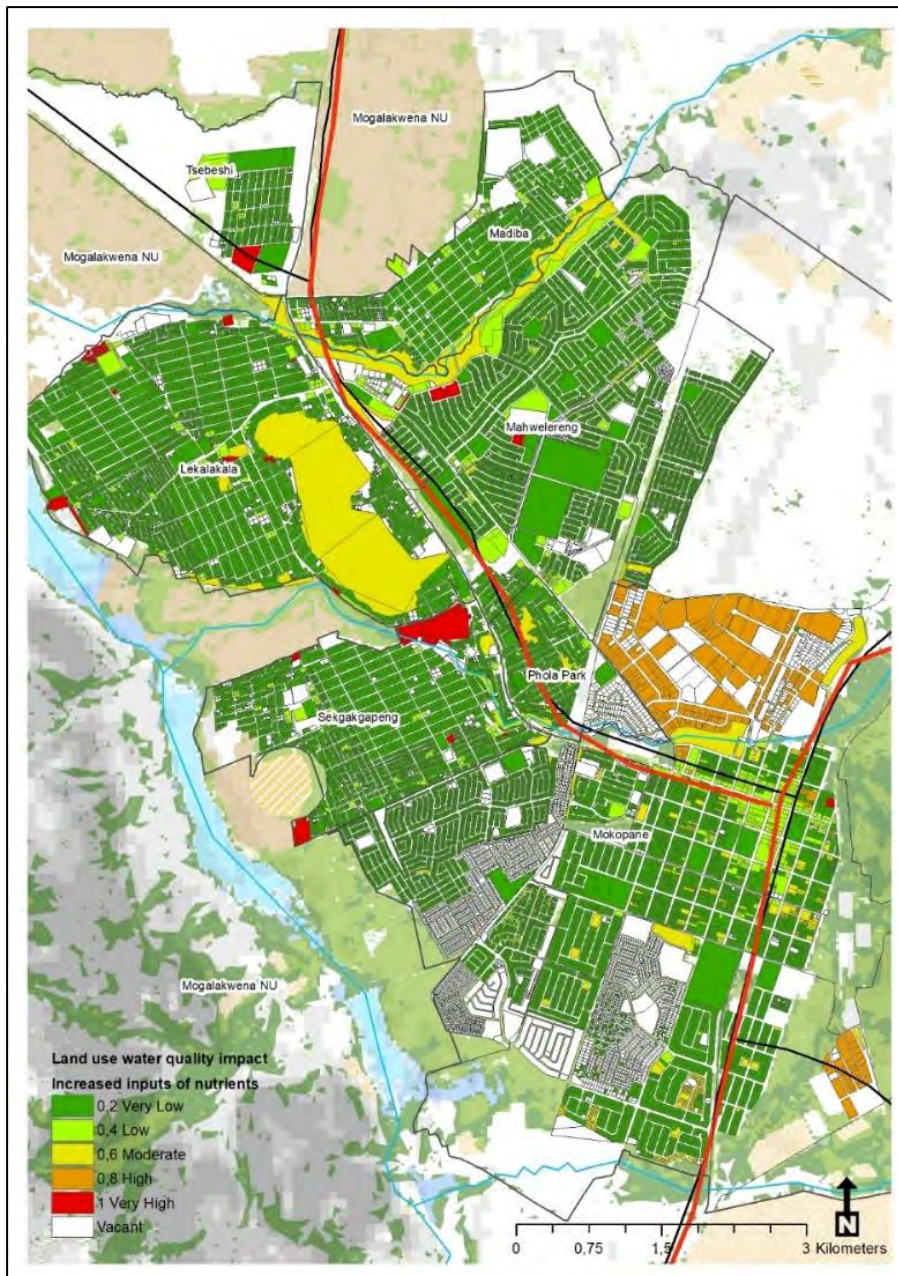


Figure 5-35: Mogalakwena's existing land use nutrients threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Increased toxic contaminants - According to the land use water quality impact spatial data, 0,2% of all urban land uses has a high toxic contamination threat rating. A total of 0.1% of all urban land use has a very high toxic contamination threats rating. This is mainly caused by Mokopane's Industrial zone. In future, Mokopane will experience an increase of 0.3% in very high threat ratings. Industrial, public services infrastructure and residential land uses poses the biggest threat for causing increased toxic contamination. The above information is illustrated spatially in Figure 5-36.

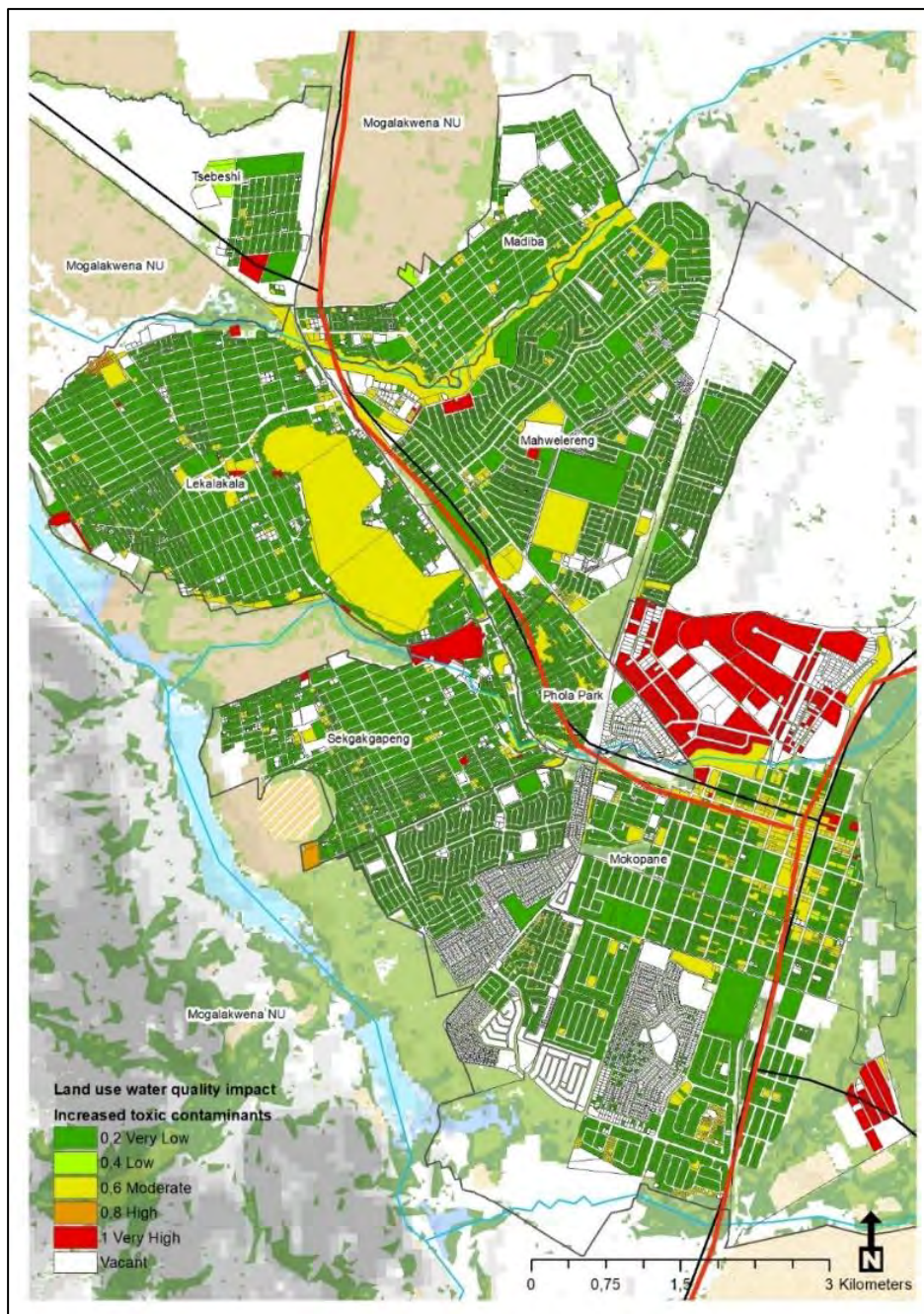


Figure 5-36: Mogalakwena's existing land use toxic contaminants threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

The concentration of salts (salinization) - According to the land use water quality impact spatial data, 1.9% of all urban land use has a high to very high salination threats rating. In future, salinization threat is likely to increase as both land use with very low threat rating will decrease while land use with a high threat rating will increase. According to the spatial data, industrial and public service industries has the highest risk of causing increased salination in stormwater resources. The above information is illustrated spatially in Figure 5-37.



Figure 5-37: Mogalakwena's existing land use concentration of salts threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Pathogens (i.e. disease-causing organisms) - According to the land use water quality impact spatial data, 1.5% of all urban land use has a high to very high pathogens threat rating. In future, the percentage of land use with a moderate threat rating will increase by 0.3%. According to the spatial data public service industries, industrial; residential informal has the highest risk of causing increased nutrients in stormwater resources. The above information is illustrated spatially in Figure 5-38.

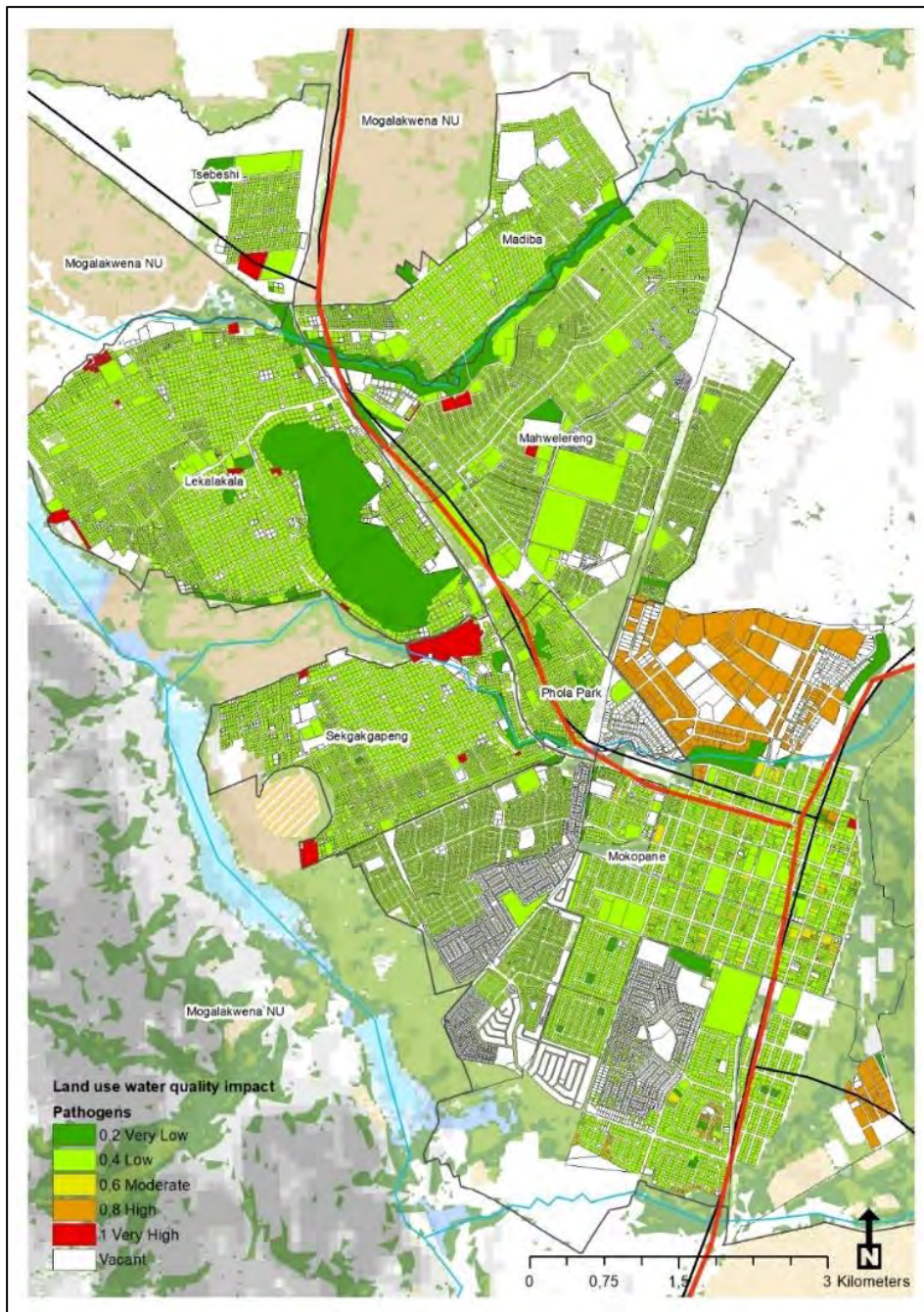


Figure 5-38: Mogalakwena's existing land use pathogen threat rating

Source: Own Construction (2018) based on Macfarlane *et al.* (2014)

Figure 5-39 illustrates a consolidated network of Mogalakwena's remaining natural and near-natural landscapes consisting of all existing Public Open Spaces, Private Open Space, all other natural and near-natural landscapes including rivers, wetlands, untouched CBAs and ESAs as per the land cover data and all existing vacant land.

Although this is not a detailed representation of a blue-green corridor, combined with the high land use water quality threats spatial data, it's possible to identify certain areas where land use water quality interventions should be prioritized. Vacant land, within the existing settlement boundaries, should be connected to one another as far as possible to create an integrated blue-green corridor. Blue-green corridor development zone - representing a consolidated network of ecological Infrastructure.

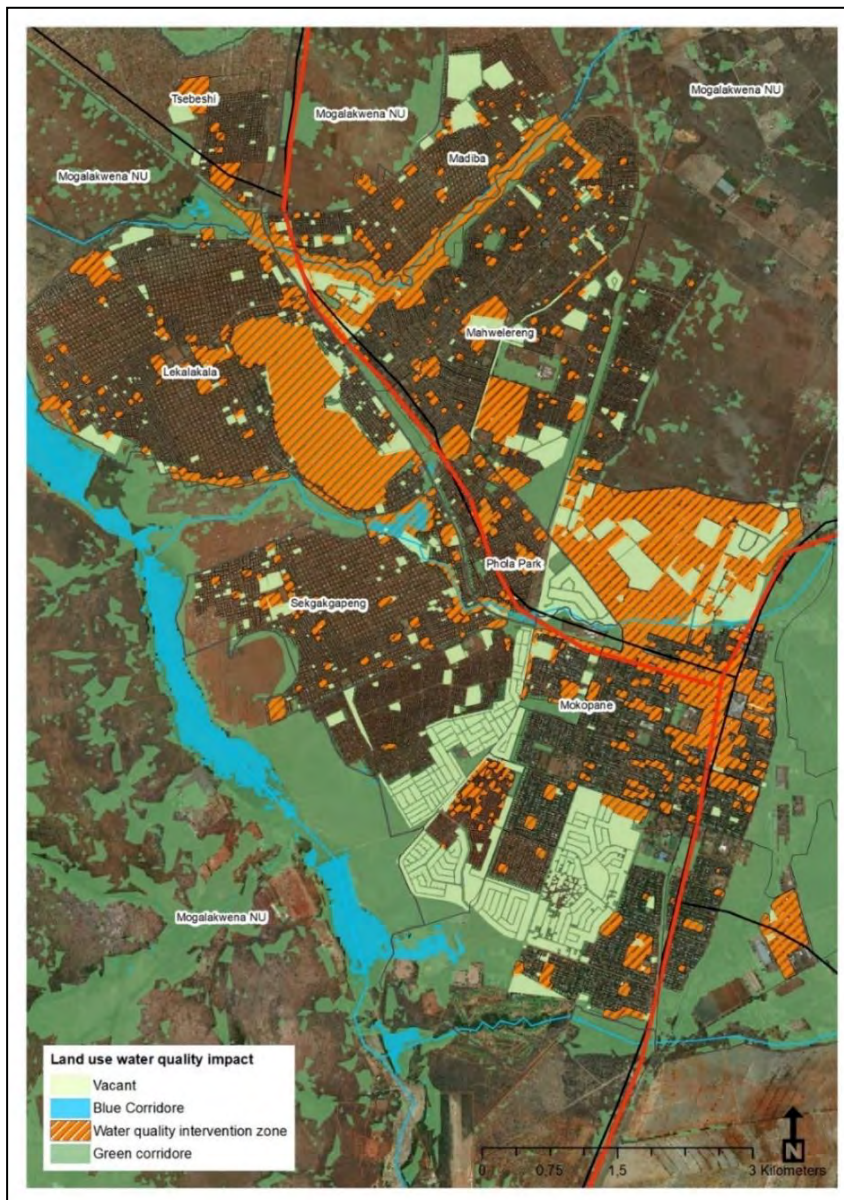


Figure 5-39: Mogalakwena's Land Use Water Quality Intervention Zone

Source: Own Construction (2018)

The impact of land use on water resource quality is not mentioned once in Mogalakwena's existing SDF or LUS.

5.4.2.2.2.3 Land use water quality analysis: Key findings and conclusions

The evidence based land use water quality analysis provides enough evidence that the change in land cover as a means to accommodate land uses has a direct quantitative impact on stormwater runoff. Spatial proposals and land use management in areas identified as Land Water Quality Intervention Zones should make use of the detailed calculations and technical illustrations of the South African Guidelines for Sustainable Drainage Systems (Armitage *et al.*, 2013). The aim of the Land Use Water Quality Intervention Zone is to reduce the qualitative impact of land use on stormwater resources by developing a Water Sensitive Urban Design Plan / Precincts Plan informed by the twelve families of SuDS options, designed to maintain pre-development conditions which includes Bio-retention areas; Detention ponds; Filter strips; Green roofs; Infiltration trench; Multi-purpose detention pond; Permeable paving; Rainwater harvesting; Retention ponds; Wetlands and Soakaways (see discussion in Section 4.3.1).

In both case studies, it became apparent that the industrial zone causes the highest level of threat to local water resources. Industrial areas usually consist of large buildings – providing large surface areas for rainwater harvesting. Although rainwater harvesting as discussed as an intervention to reduce water demand, it also assists in reducing the volume of stormwater. As a source control measure, building in found within Land Water Quality Intervention Zones should implement rainwater harvesting technologies to reduce runoff. This can be achieved through a land use scheme's building controls regulating the following:

- The building control should mandate the use of corrugated iron as the roof material, constructed at an angle which is slightly pitched (decrease the harvesting potential) - typically associated with modern buildings.
- Parking areas and driveways of largescale developments typically found in Industrial precincts, shopping centres, business precincts or apartment blocks should make use of underground stormwater harvesting storage solutions can be accommodated underground of building and parking areas.

Zoning can also be used to increase densities or coverage of land within Water Quality Intervention Zones:

- Zonings can be used to increase development densities and building heights (go “up” instead of “wide”). By increasing densities within the existing development footprint natural vegetation will be protected from land cover change, leaving it naturally permeable, filtering out contaminants – reducing the volume of contaminated runoff before it enters the larger water bodies.

- Zoning can allow for increased coverage as a development incentive if the developer implements some form of water harvesting solution which captures e.g. 30% of the total volume of runoff.
- FAR (Floor areas ratio) – refers to the percentage of land which may be developed. However, this does not include driveways, parking areas or verandas. These surfaces are mostly impervious and affect stormwater quality. FAR should be recalculated to include these surfaces for that a recommended permeability percentage can be prescribed to a site. Properties located in the Water Quality Intervention Zone should retrofit residential driveways; parking bays; private roads, public service roads and fire engine lanes; industrial storage and loading areas; and bike pathways, walkways, terraces and around swimming pools with permeable paving to reduce the rate of stormwater runoff.

As for local controls in Water Quality Intervention Zones, the Water Urban Design Plan / Precincts Plan should make recommendations for the second phase of the SuDS treatment train consisting of natural channels instead of pipes and concrete-lined canals. A detailed stormwater modelling assessment will be required to determine the direction and volume of stormwater flow. As for Lephalale and Mogalakwena's Water Quality Intervention Zone the following SuDS should be considered and implement in areas (blue-green corridor) closest to where land use causes high levels of pollution:

- Filtered swales and filtered strips should be implemented in road medians, road kerbs and verges, car parking runoff areas, parks and recreational environment. Filtered strip specifically should also be along stream banks as vegetated buffers systems and in public open spaces serving an area smaller than 20 000 m² with slopes between 2% and 6%.
- Infiltration trenches should be utilised throughout the Water Quality Intervention Zone adjacent to impervious areas such as roads, footpaths, parking lots and other hardened areas as they are very effective in removing suspended particulates from stormwater.
- The water sensitive Climate analysis already identified Sand filters as feasible SuDS Selection as the most efficient in arid regions with high evaporation rates where limited rainfall. Sand Filters should be implemented on sites where the impervious area is less than 8 000 m²; however, sand filters may be designed to manage stormwater runoff from areas as large as 100 000 m².

As for regional controls in the Water Quality Intervention Zones, the Water Urban Design Plan / Precincts Plan should make recommendations for the final phase of treatment train before contaminated stormwater it is discharged to the receiving waters. Both Lephalale and Mogalakwena have river networks running through their Water Quality Intervention Zone. The blue-green corridor should be utilised for either

- detention ponds or detention basins as they are ordinarily dry SuDS systems and require only 2% its contribution impervious area.

- Constructed wetlands as they are mostly found in flat areas (like the topography found in Lephalale and Mogalakwena's Urban areas), serving catchments larger than 10 ha. Since both municipalities have ample vacant land, the Water Sensitive Urban Design Plan / Precincts Plan should identify municipal owned vacant land to be utilised for constructed wetlands. Pocket wetlands are typically less than 400 m² and serve developments no greater than 40 000 m².

In essence, natural open spaces should be utilised for green infrastructure to harvest and treat stormwater runoff. Furthermore, the beatification of business and industrial zones through WSUD and other green design elements encourages investment potential and a sense of places. Cities and settlements have a responsibility to restore ecological functions through layout, design and use of infrastructure. One of the key approaches in achieving this is to increase the permeability of built-up areas. Growth management and density strategies can be used to achieve this.

There is scope for future research to develop an in-depth methodology to determine the land use water quality impact and also which variety of SuDS selections will be most suitable for certain precincts based on the land use water quality threats rating. See further recommendations on how this analysis can inform municipal planning tools to achieve WSS as provided in Chapter 7.

5.4.2.2.3 Settlement form: Densification

Settlements have three ways to accommodate population growth. They can either increase their carrying capacity, expand their boundaries, or create a spatial system with many new town centres or use a combination of all three of the above. Typical South African settlements are characterised to be of low density and of sprawling nature. In other words, they choose to expand their development boundary. The unnecessary expansion impact on water resources are two-fold:

- Services delivery impact
- Ecosystem related impact

In terms of services delivery impact, low density sprawling layouts require extensive services distribution networks. This specifically relates to the density and location of development. According to Frank (1989), infrastructure costs are highest in situations of low density and for development located at a considerable distance from centralised public services. However, this should be read within contexts as South Africa's Redbook which claims that the total cost of water and sewerage provision increases as density increases, with larger and more expensive piping requirements (CSIR, 2000:6).

On the other hand, because costs are shared by more users, the net cost is lower. The longer the length of a network the higher the cost of construction, operations and maintenance (Ibid.). In addition to the cost of physical infrastructure, less energy is required to distribute water and wastewater from point A to B in denser settlements which means that less water is required to generate energy (water energy nexus). Higher density development and compact settlement structures are therefore less resource intensive. Sprawling low-density developments also have a higher UARL as the potential for water loss becomes greater as the length of the distribution network increase, if the construction, operations and maintenance are not carried out to a specific standard. By reducing the length of a pipeline within a compact settlement structure, less water can leak from the system, reducing the rate and volume of non-revenue water within a settlement.

In terms of ecosystem-related impact, low density, sprawling layouts commence valuable natural landscapes required for the healthy functioning of the hydrological cycle. Higher density development occupies less surface areas, leaving more natural landscapes intact necessary to replenish water resources. The process of replenishment also treats water, keeping it in a healthy ecological condition. Increased impermeable surfaces also affect the quality of stormwater runoff.

The purpose of this analysis is to determine the extent of existing development density and the availability of vacant land within the existing built-up area to be prioritized for future development. Table 5-31 describes the methodology used to conduct a density analysis.

Table 5-31: Settlement form: Densification

Map	Determine the spatial location and extent of Method / Steps
Land use data	...Settlement form and function 1. The land audit should provide sufficient information to make a visual assessment of the settlement form and function.
Land use data Subplace data Existing urban edge (if available)	...existing development density and the availability of vacant land within it. 2. A "New" – "Shapefile" – "Feature type" – "Polyline" labels "Development Edge" was created in GIS and a strict urban edge traced as close as possible to the existing was built-up footprint. 3. The net household/residential density was calculated next. Using the "Select by Attribute" in the <i>Land_use.shp</i>, and the "Get Unique Values" function and select "Residential" as the attribute to be identified. 4. The selected "Residential" features were exported as a new shapefile. In the newly exported shapefile, a "new field" labelled "Density_m²" was added to the attribute table and the "Calculate Geometry" function was used to calculate each settlement's residential footprint in m². 5. Once calculated the "Spatial Join" tool was used to join the residential land uses to the subplace cadastre which already has the number of households per subplace linked to its attribute table. 6. Another "new field" was added to the shapefiles attribute and the "Field Calculator" function was used to calculate:

	$Net\ density = \frac{\text{number of dwelling units}}{\text{total residential land area}}$ 7. The next was to identify well located vacant land within the newly delineated urban edges. The “<i>Select by attribute</i>” function was used to identify all vacant erven; the extent was calculated using the “<i>Calculate geometry</i>” function. 8. Lastly the “<i>Define query</i>” tool was used to identify all vacant and municipal owned land within the exiting development edges.
Density Water Loss Model - Analysis takes place in Excel and in GIS but the information is presented in a graph (no mapping)	... the volume of Unavoidable Annual Real Loss (UARL) of a system in good condition by density. The following model (see description below) was developed (by the author) to determine the impact of density on UARL. The hypothesis is that higher density development will have a reduced volume of UARL as UARL can occur at three components of infrastructure: • Transmission and distribution mains (excluding service connections) • Services connections, mains to street/property boundary • Private underground pipe between street property and consumer meter Increasing densities will reduce the length of pipeline and the number of services connections, ultimately reducing the UARL potential. This analysis was not conducted for Lephalale nor Mogalakwena as spatial data was a severe limitation.

Source: Own Construction (2018)

Density Water Loss Model - Calculated components of unavoidable annual real losses (UARL)

The following equation calculates the volume of UARL of a system in good condition, based on the density of connections (number) and the length of pipe.

$$UARL = ((18 \times LM) + (0.80 \times Nc) + (25 \times Lp)) \times P$$

Where:

UARL = Unavoidable annual real losses (L/day)

Lm = Length of mains (km)

Nc = Number of services connections (mains to meter)

Lp = Length of unmetered underground pipe from street to customer meter (km)

P = Average operating pressure at average zone point (meters)

However, calculating the impact of various densities requires a slightly different yet innovative approach. The following section explains the methodology to determine the UARL by density (also referred to as the (Density Water Loss Model) adopted for Ekurhuleni Metropolitan Municipality as the author was unable to conduct the calculations for Lephalale and Mogalakwena Local Municipality due to limited spatial data on water infrastructure distribution networks.

Ekurhuleni was identified as a good case study as the municipality has a wide range of housing densities (Very low; low; medium and high) and the Author had access to spatial data on Ekurhuleni's water distribution network and spatial data of the number of customers (all water users) by subplace.

i) To determine UARL by density in order to prove that higher density development has a reduced potential (as a percentage) of UARL, the following data should be gathered:

- Spatial data on the water distribution network (source: Ekurhuleni Asset Register)
- Cadastral spatial data

ii) From the above data source, the following information was extracted:

- To determine length of mains (L_m), the water distribution network spatial data was extracted from Ekurhuleni's Municipal Asset Register.
- The number of services connections (N_c) is an assumed figure based on the cadastral spatial data that each erf has a services connection.
- To determine the length of Pipeline (L_m) pipe diameter was used to reclassify the network into mains and underground pipe networks, pipe smaller than 50 mm in diameter was the selected as the underground pipeline network. This provides sufficient information to determine the length of unmetered underground pipe from street to customer meter (L_p).
- Based on information provided by Professional Engineers, the average operating pressure at average zone point (P) was set at 49.
- Regarding density, the erf cadastre, as well as the number and type of customer (water users) per property, was used to determine the net density (number of households per hectare) on subplace level. Densities were classified as low, medium and high.

iii) Based on the above information the following was determined:

Total L_m = Length of mains (km) = 8 242 394 km

Total L_p = Length of unmetered underground pipe from the street to customer meter = 392 524 km

Total N_c = 68 950

iv) The above information is sufficient to calculate the UARL in a water distribution network, however, the density is still required to prove the hypothesis. To determine the UARL by density, use the "Spatial join" function in GIS to link the UARL to the sub-place density information. This means that all other attributes L_m , L_p and N_c now have a density (low, medium and high) assigned to it. The final step is to export the spatial data in Excel where the data can be analysed using a pivot table to determine the UARL variants per subplace. Using Ekurhuleni as a case study to implement the Density Water Loss Model, the following findings were made, see Table 5-32 and Figure 5-40.

Table 5-32: UARL by settlement density

Density	UARL (Litres per day)	Number of customers serviced	Litre/Customer/Day
High	104 405	23 918	4
Medium	88 486	13 471	7
Low	332 200	26 634	12

Source: Own construction (2018)

Table 5-32 and Figure 5-40 explains that the UARL (litres per day) in Ekurhuleni's high-density areas is 104 405, in medium density areas it's calculated at 88 486 and in low-density areas the UARL is 332 200. Figure 5-40 proves that in high-density development, the litres of water lost per day equates to 4 Litres per persons per day. In Areas where development density is low, the average litres of water calculated as UARL is three times more at 12 Litres of water per person per day.

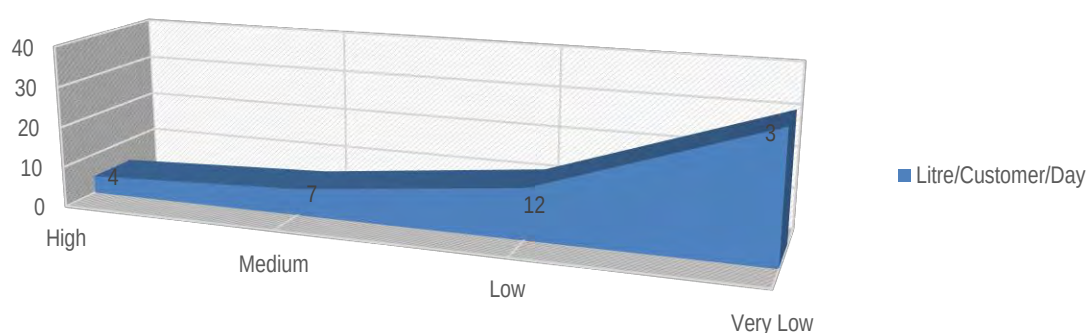


Figure 5-40: UARL by settlement density

Source: Own construction (2018)

From the above analysis, a strong argument for higher density development can be made as the volume of UARL is almost three times less per person in higher density development areas than in sprawling low-density settlements – the latter which is also a common characteristic of most settlements in South Africa.

Section 5.4.2.2.3.1 and Section 5.4.2.2.3.2 to follow summarises and spatialise the key findings of the settlement form (density) and function analysis conducted for both Lephalale and Mogalakwena Local Municipality. Section 5.4.2.2.2.3 reflects on the key findings and draws a conclusion.

5.4.2.2.3.1 Lephalale settlement density analysis

Lephalale Local Municipality land audit provides sufficient spatial information to make a visual assessment as to where development has taken place over time as well as where infill development should be prioritised in future. In terms of density, the spatial data indicates that Marapong has by far the highest Gross Household Density at 16.6 households per hectare followed by Moong, Bossche Diesch, Mmaletswai, Sefetlhogo and Thabo Mbeki with densities above 4 households per hectare. This is however extremely low gross household densities. Most rural settlements have higher densities than that of Lephalale's main urban centre. This low density is mainly attributed to the node's linear shape characterised by leapfrog develop stretching over 13 km (Lephalale Local Municipality, 2017a:81). In recent years, a number of new townships have been registered on the periphery of the town, most notably Ellisras ext. 102 (Altoostyd); 70; 86; 87 and 97. To date, more than half of all stands (54%) in the Ellisras Marapong node are vacant (Ibid, 2017:67).

Based on the facts that more than half of Ellisras and Marapong's stands are currently vacant and also identified as a provincial growth node, the municipality should prioritise infill development in this node for the next 30-years until all vacant land within the existing development boundaries has been developed.

Due to a lack of spatial data, Density Water Loss Model could not be conducted for Lephalale Local Municipality. However, based on the information provided in that increased densities facilitate a reduction in UARL in a water distribution network. Promoting higher density development and infill development in Ellisras and Marapong can contribute to achieving the NDP target to reduce urban water demand by 15% less than that of business as usual.

Lephalale's existing SDF adopted an aggressive growth management strategy aimed at rectifying the fragmented spatial form of Ellisras / Marapong node. It states that the municipality should not approve any new township establishment applications until such a time when the majority of vacant stands have been taken up. The SDF also acknowledges the benefits of a compact city and highlights that infrastructure cost is cheaper in compact cities. However, the existing SDF does not make any mentioning of the water quantity benefits in terms of reduced UARL in a water distribution system.

5.4.2.2.3.2 Mogalakwena settlement density analysis

Mogalakwena Local Municipality land audit also provides sufficient spatial information to make a visual assessment as to where development has taken place over time as well as where infill development should be prioritised in future. In terms of density, the spatial data indicates that Mahwelereng has by far the highest Gross Household Density at 9.4 households per hectare followed by Phola Park, Sekgakgapeng, Tsebesi, Tshamahansi, Madiba, Ga-Kgubudi, Ga-Letwaba and Lekalakala with all have densities above 4 households per hectare. Although these calculations are based on gross density and not net density, it provides a good indication as to where higher density development can be found.

Once again, due to a lack of spatial data, the Density Water Loss Model could not be conducted for Mogalakwena Local Municipality. However, the amount of available vacant within the municipalities main urban node is sufficient to support future growth for the next 5 to 10 years. In doing so, the municipality can reduce the volume of UARL and protect natural environments for future destruction.

5.4.2.2.3.3 Settlement form, Densification: Key findings and conclusions

According to the Limpopo Water Management Area North Reconciliation Strategy (AECOM, 2016:2-7), the unit costs of service delivery are generally lower in urban areas due to the higher settlement densities that are achieved. Increased densities also have the potential to reduce the volume of UARL throughout a water distribution network, effectively contributing to water conservation and demand management. Due to a lack of spatial data, the researcher was unable to conduct the Density Water Loss Model for Lephalale and Mogalakwena local municipality. Nevertheless, the analysis still confirmed that both municipalities have the opportunity to increase their densities within their existing built-up footprints as no truly high densities were found in either municipalities. Furthermore, more than half of exiting proclaimed erven still remain vacant/unoccupied. In future, both municipalities should prioritise high-density infill development within the existing settlement boundary, until such time comes that the carrying capacity has been fulfilled. This can be achieved through two planning strategies, a densification strategy and a growth management strategy. See further recommendations on how this analysis can inform municipal planning tools to achieve WSS as provided in Chapter 7.

5.4.2.3 Water Sensitive Socio-Economic Analysis

The Socio-economic analysis strongly relates to the biophysical and built environment ability to provide services to residents and economic sectors. The socio-economic analysis is mostly informed by statistical data published by the Stats SA. The significance of statistical data is often lost in SDFs as most of the data have no spatial reference assigned to it. In addressing water sensitivity as part of the analysis, the aim to identify areas where new technologies related to water and sanitation services can be socially embedded, both physically and institutionally. The analysis also determines the level of services to be provided in future - informed by realistic targets and considering not only resource security but also financial sustainability. One of the limitations of this analysis is that 2016 census data is only available on municipal level, and not subplace level. For this reason, 2011 census data had to be used throughout the Water Sensitive Socio-economic Analysis.

5.4.2.3.1 Services assessment: Potable water and sanitation services

Access to piped water is one of the key indicators utilised in the Multiple Deprivation Index. The Water Sensitive Socio-economic Analysis aims to determine the current household level of access to services (potable water) as well as backlog (spatially). Backlog is determined as any level of service not equal to, or below the basic levels of services description as stated in the national standards for levels of services as prescribed under section 9(1) of the Water Services Act, 1997 (Act No. 108 of 1997) see Table 5-33.

Table 5-33: Levels of services - Water supply and sanitation methodology

Levels of services: Water supply	Description
Basic level of domestic water supply	A basic (or RDP) household water supply is defined by the Strategic Framework for Water services (2003) as either 25 litres per person per day, or 6000 litres per household per month, supplied to the following criteria: 1. A minimum flow rate of net less than 10 litres per minute; 2. Within 200 meters of a household, however, according to the DWS (2015), Cabinet approved that basic water supply be amended from within 200m to within the yard, although this has yet to be promulgated; 3. Interruption of less than 48 hours at any one time and a cumulative interruption time year of less than 15 days/year; and at a potable standard (SANS 241 or South African Water Quality Guidelines published in 1998)
Interim water supply solution	The DWS priorities all communities living in a settlement that is greater than 50 households within these areas will be priorities to receive at least a minimum interim water supply by 30 June 2015. The Minimum standard of interim/ intermediate water supply is: 1. 10 litres per person per day within 500 meters of a household and fit for human consumption (SANS 241).

	2. No Consumer is without a water supply for more than seven full days in any year and no more than three consecutive days.
Longer term domestic water supply	Medium and higher levels of Domestic Water is aimed at ensuring that all households receive 50 to 60 litres per person per day via an individual connection, either in the house or in the yard.

Source: Strategic Framework for Water services (2003:5)

The provision of sanitation is a key development intervention – without it, ill health dominates a life without dignity. Achieving real gain in sanitation coverage in South Africa has been slow as many households still lack access to a basic level of sanitation. Despite the slow pace of services delivery, government and communities tend to choose highly technical sanitation solutions which in the long-term, are unaffordable and/or unsustainable, most particular, the implementation of water-intensive sanitation technologies in water-scarce regions of the country. Table 5-34 provides a description of the minimum national standards for water services as per section 9(1) of Act No. 108 of 1997. Backlog to sanitation services is currently determined as access to anything but a bucket toilet.

Table 5-34: National standards for sanitation services

Level of services	Description of level of service
Basic level of domestic sanitation:	A Ventilated Improved Pit Latrine (VIP) which is a dry toilet facility
	The preferred temporary sanitation solution is a chemical toilet
	Bucket toilet is unacceptable
Higher level of domestic sanitation:	Any of the following: Full waterborne sanitation, septic tank, soak-away and urine diversion toilets.

Source: Strategic Framework for Water services (2003:5)

In terms of the affordability of services, the level of access to services provided to households holds many financial implications for the municipality as households are unable to pay for services. Nonetheless, section 27 (1)(b) of Constitution puts forward the right of access to sufficient water and sanitation services. Severe poverty conditions are assumed to prevail for households earning less than R 19 201/a. These households will generally be unable to pay for the cost of municipal services, although they may be in a position to contribute time and labour for community work as payment for municipal services. Low to middle-income households are classified as those with incomes between R 19 601 and R 76 400/a. These households should be in a position to contribute at least a portion of the cost of municipal services, even though they may be unable to pay the full cost. Households earning more than R 76 400/a are classified as high-income for the purpose of this analysis. Households in this group should be expected to pay full cost recovery rates for the services that they receive.

This section acknowledges that there are many water mandatory strategic water sector plans – of which the main purpose is to address future water need and demand. However, in the event that such information is not available (like in Lephalale and Mogalakwena Local Municipality) the water sensitive socio-economic analysis can contribute to some level of understanding as to where future services and level of services should be prioritised. Table 5-35 presents the methodologies used to conduct a Water Sensitive Socio-economic Analysis.

Table 5-35: Socio-economic analysis Methodology

Map	Determine the spatial location and extent of Method / Steps
All basemap data - A01 ; A02; A03; A04; A05; A06; A08; A09; A10; A11; A12; A13; and A14 Infrastructure data - A20; A21; A22; A23; A24; A25; A26; A27; and A28 Subplace boundary - A07 StatsSA – Census 2011 - Household water source by subplace	...The source of main water supply per Households on subplace level - Download the 2011 “water source by subplace” census data in excel. - Calculate the percentage of household’s access to water sources by dividing each category through the total number of households in the municipality. - Generate a linkable SG code in the excel sheet to be uses as a link to the “subplace” - Use the “join” function in GIS to link the newly generated SG code in the census spreadsheet to the municipal subplace shapefile. - Use the “symbolology” tool – “show” - “Pie” and select the following attributes to be displayed the percentage of households by subplace which access to main water source is: - Regional or were local water scheme (grid) - Groundwater - Rainwater tanks - Springs, rivers, streams, dam, pools and stagnant water - Water tankers and other
StatsSA – Census 2011 Household access to piped water by subplace	...household access to levels of potable water services per subplace - Repeat Step 1 but download 2011 “access to piped water by subplace” - Repeat step 2 – 4 - Use the “symbolology” tool – “show” - “Pie” and select the following attributes to be displayed the percentage of households by subplace which has access to piped water: - Piped water inside dwelling/institution - Piped water inside yard - Piped water on community stand – distance less than 200m form dwelling - Piped water on community stand – distance greater that 200m form dwelling - No access to piped water
StatsSA – Census 2011 - Household access to piped water by subplace - Annual household income	... unaffordable high levels of household potable water services per subplace - Repeat step 1 but download 2011 “annual household income distribution by subplace” in excel. - Regroup the “annual household income distribution by sub-place” as per the following categories: - Severe poverty (households earning less than R19 000/a - Low income (households earning between R19 601 and R76 400/a) - High income (households earning more than R 76 400/a) - In Excel, use the “access to piped water” census data to filter and determine the % of households classified as severe poverty (unable to pay for services) but has access to a very high level of services such as “access to piped water in dwelling”

	12. The opposite assessment was also conducted to determine where most households within a subplace is able to afford a higher level of services but is currently receiving a lower level of service. 13. Repeat step 3 and step 4 14. Use the “symbolology” tool – “show” - “graduate symbol” and select the following attributes to be displayed the percentage of low-income (severe poverty) households with access to piped water inside their dwellings: • 0.0% - 20% • 20.1%-40% • 40.1% - 60% • 60.1%-80% • 80.1%-100%
StatsSA – Census 2011 Household asses to sanitation services	...household access to levels of sanitation services per subplace 15. Repeat Step 1 but download 2011 “access to piped water by subplace” 16. Repeat step 2 – 4 17. Use the “symbolology” tool – “show” - “Pie” and select the following attributes to be displayed the percentage of households by subplace which has access to sanitation: • No sanitation or bucket toilet • A Ventilated Improved Pit Latrine (VIP) which is a dry toilet facility • Chemical toilet • Any of the following: Full waterborne sanitation, septic tank, soak-away and urine diversion toilets.
Stats SA – Census 2011 • Household access flush toilet (Waterborne sanitation) • Annual household income	... unaffordable high levels of household access to waterborne sanitation per subplace 18. Repeat step 1 19. Repeat step 9 and step 10 20. Repeat step 11 but use access to flush toilet as the filter 21. Repeat step 14 to determine where unaffordable levels of sanitation services by subplace is provided. 22. Repeat step 14 but display level of access to sanitation by household income.
Final Map	
The percentage of households and the access to main water source by subplace (based on 2011 census)	... determine in which subplace are households more dependent on groundwater (boreholes) and rainwater tanks as their main source of water.
The percentage of households and the access to piped water by subplace (based on 2011 census)	...Determine which subplaces have access to adequate levels of services and where backlog in services is experienced.
The percentage of affordability level to levels of potable water services (based on 2011 census)	...Determine where unaffordable high levels of services are provided to settlements
The percentage of households and the access to sanitation services by subplace (based on 2011 census)	...Determine which subplaces have access to adequate levels of sanitation and where backlog in services is experienced.
The percentage of affordability level to levels of sanitation services (based on 2011 census)	...Determine where unaffordable high levels of sanitation services are provided to settlements

Source: Own construction (2018) see Annexure E for data source list

Section 5.4.2.3.1.1 and Section 5.4.2.3.1.2 to follow summarises and spatialise the key findings of the Water Sensitive Socio-economic Analysis conducted for both Lephalale and Mogalakwena Local Municipality. Section 5.4.2.3.1.3 reflects on the key findings and draws a conclusion.

5.4.2.3.1.1 Lephale services assessment: Potable water and sanitation services

Lephale Local Municipality has two registered Water Services Providers which includes Exxaro/Khumba Resources and Eskom operating at Zeeland and Matimba supply system. In 2012, the Zeeland supply system provided water services to 20 373 people and calculated an average daily consumption of 893.34 (litres/person/day) whereas Matimba serviced 15 000 people and calculated an average daily consumption of 586.67 (l/p/d). In 2012, Exxaro's Zeeland Water Treatment Works (WTW) was awarded the prestigious Blue Drop Certification (DWS, 2014). However, in 2014 this status could not be maintained and was scored 85% (below the certification). Reasons for the downgrade is currently unknown.

In terms of water services, the 2017/2018 Lephale Municipal IDP explains that the bulk water infrastructure services within the municipality's urban node "is pumped from the Mokolo dam to the Wolvefontein storage dam, from where it gravitates down to Zeeland water purification plant and the purification plant at Matimba power station. Bulk raw water then gravitates down to the Grootegeluk mine and Eskom's Matimba power station. Lephale and Onverwacht are then supplied with water that gets purified at the Zeeland WTW (owned and operated by Exxaro resources). The effluent gets treated at Paarl WWTW" (Lephale Local Municipality, 2017b:50). The above-described infrastructure provides for the bulk of Lephale's urban areas as well as a large component of the municipality's rural areas with water and sanitation services. According to the census 2011 statistical data, Lephale Local Municipality and its two Water Services Providers were successful in increasing access to basic services between 2001 and 2011 from 22,4% to 31,4% (see Figure 5-41) (Stats SA, 2011).

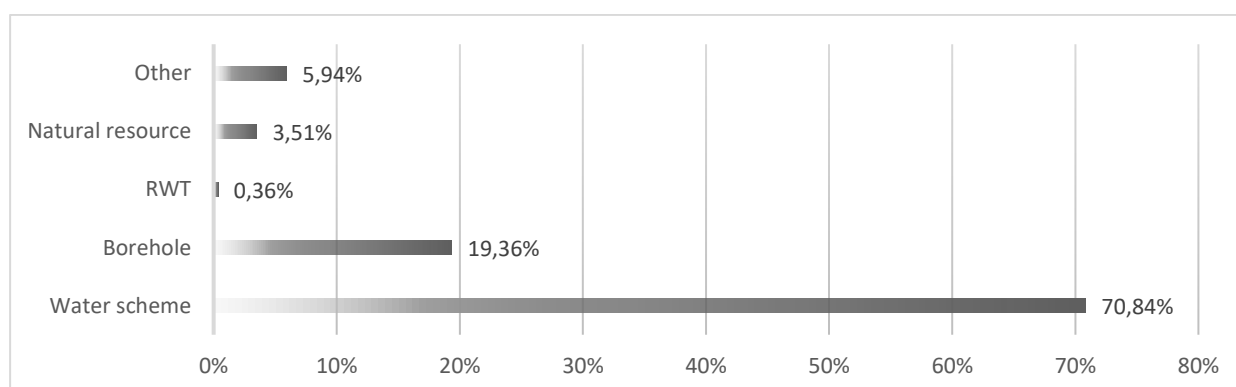


Figure 5-41: Lephale % of household access to main water source

Source: Own Construction (2018) based on Stats SA (2011)

In terms of household access to water source, the 2011 census data reports that 70.84% of Lephalale's households received their main source of water through the regional/local water scheme. 19.36% Of all households relied on groundwater as their main sources provided by local boreholes; 3.51% access natural resources as their main source for domestic water use. While only 0.36% use rainwater tanks (Stats SA, 2011).

In several rural areas, the majority of household's had access to borehole water as their main source. However, in terms of the spatial data, 935 of Lephalale's existing boreholes extract water from areas with high groundwater quality concern, more specifically areas where groundwater has a very high EC concentration ($EC < 300 \text{ mS/m}$) which may lead to health risks (see Figure 5-42). Residence should be informed about this risk and in determining the future levels of services in their areas should also be informed by this risk. Furthermore, strict borehole protection zones should be implemented around each borehole, no development should take place in this zone as it may increase the risk of groundwater contamination.

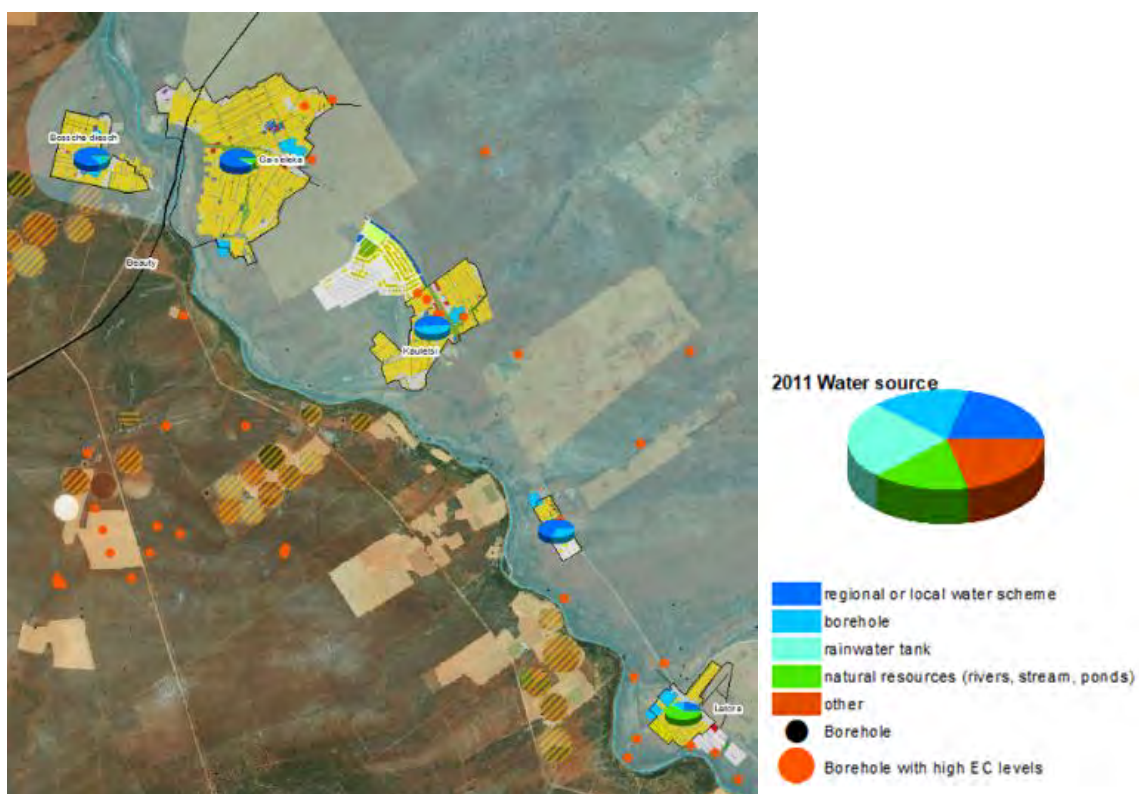


Figure 5-42: Lephalale boreholes with high levels of EC (main source of water)

Source: Own Construction (2018) based on Stats SA (2011)

Figure 5-43 illustrates on the subplace level the percentage of household access to the main source of water.

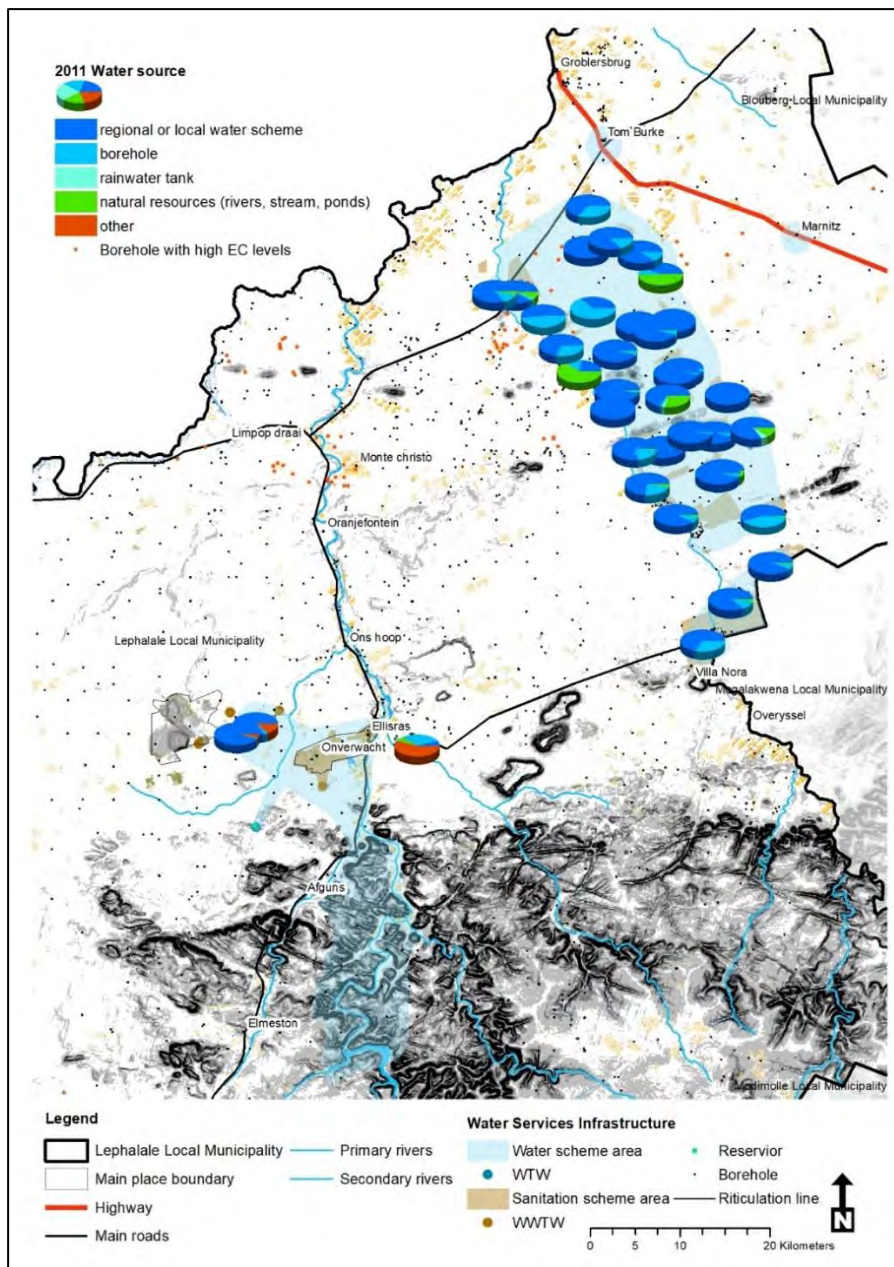


Figure 5-43: Lephalale % of household access to main water source by subplace

Source: Own Construction (2018) based on Stats SA (2011)

In terms of water supply services, a suitable (RDP) standard of water supply is to have access to piped water either inside a dwelling/yard or at least within 200 metres of the dwelling. According to the 2011 Census data, 89.1% of the households of Lephalale local municipality have access to piped water which includes the sum total of households with piped water inside dwelling/institution, piped water inside the yard and piped water on community stand: distance less than 200m from dwelling/institution. Of this 89.1%, 31.5% of the households have piped water inside their dwelling. Figure 5-44 shows access to piped water in 2011.

In terms of backlog, according to the 2011 census data, 11% of Lephalale's households experienced a backlog in access to services. Figure 5-45 illustrates that most of this backlog takes place in Thabo-Mbeki; Letora, Ga-Seleka and Kitty (Stats SA, 2011).

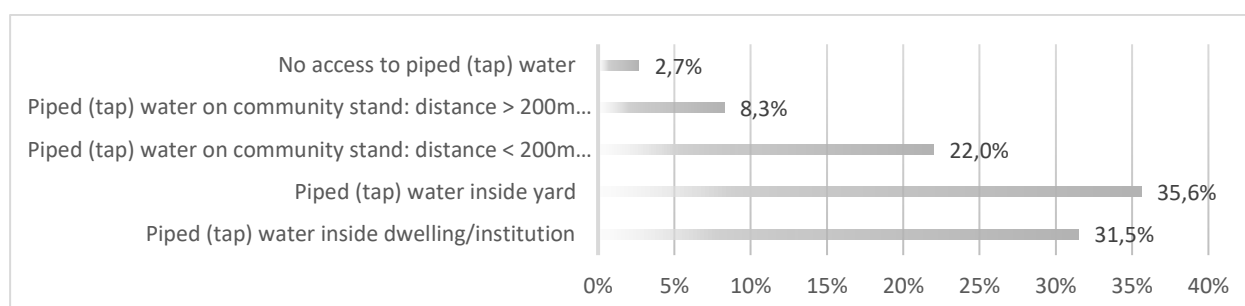


Figure 5-44: Lephalale % of household access to piped water (2011)

Source: Own Construction (2018) based on Stats SA (2011)

A more recent (2018) source of data provided by the DWS, differentiates between the access to water infrastructure which generally corresponded to the figures presented by Stats SA and access to reliable supply (DWS, 2018). The difference is that even-though there might be water distribution infrastructure, the system integrity (physical, hydraulic and chemical) could have been compromised by several factors such as leaks, lack of water pressure and contamination of water. According to Table 5-36, despite the fact that 84.95% of Lephalale's urban population has access to piped water, only 62.33% of them have a reliable supply. A similar situation is found in the rural areas where 85.35% of the population has access to piped water but only 62.45% of the population has access to a reliable supply. In both urban and rural areas almost 40% of the population suffer from non-reliable water supply. The exact spatial location on where this non-reliable supply is taking place is undetermined.

Table 5-36: Lephalale reliable water supply 2017

Reliable water supply 2017	Urban Population	Rural Population
Lephalale Local Municipality Population with access to water	84.95%	85.35%
Lephalale Local Municipality Pop with NO water	15.05%	14.65%
Lephalale Local Municipality Pop with reliability supply	62.33%	62.45%
Lephalale Local Municipality Pop with non-reliability supply	37.67%	37.55%

Source: DWS (2018)

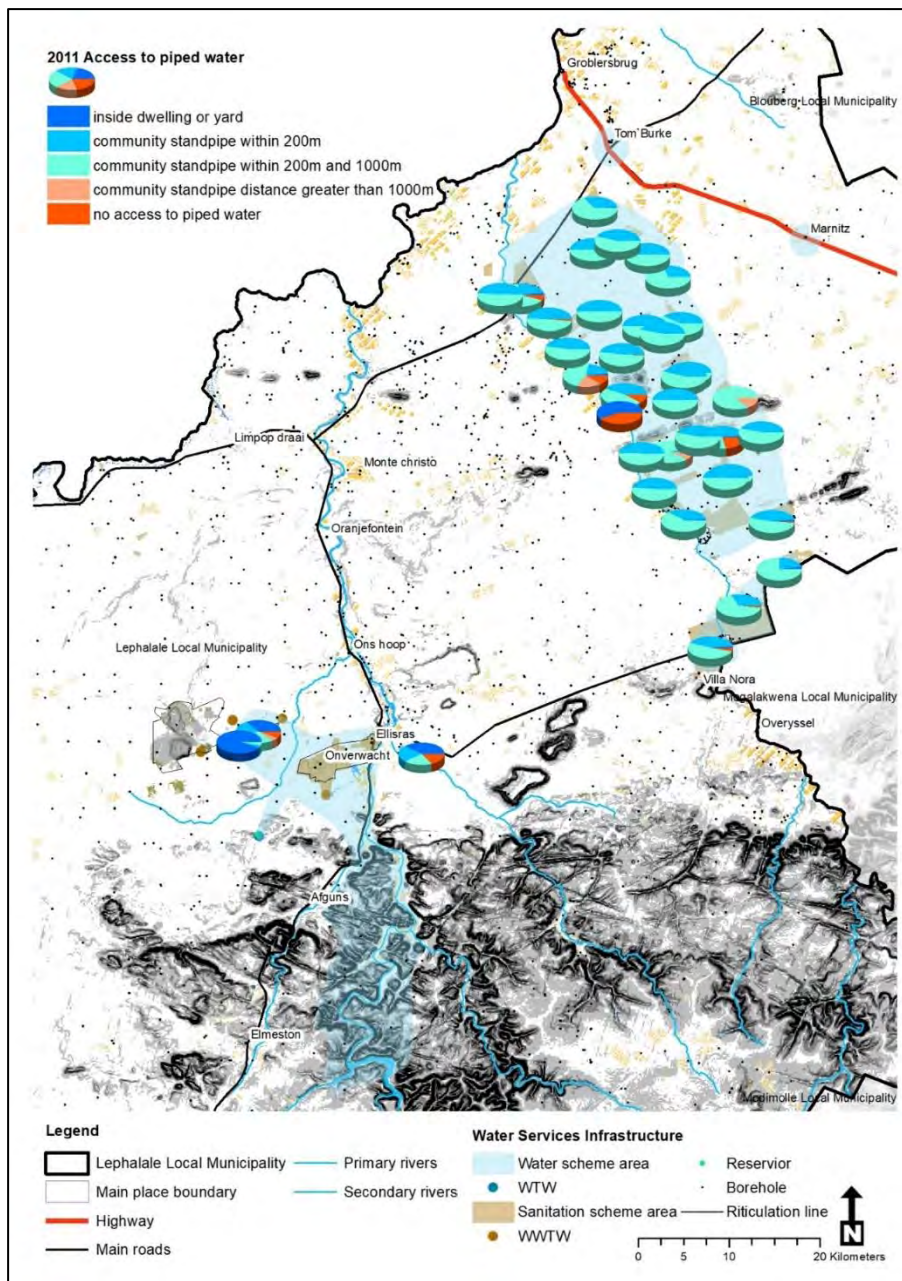


Figure 5-45: Lephalale % of household access to piped water (2011) by subplace

Source: Own Construction (2018) based on Stats SA (2011)

Regarding sanitation services, Lephalale Local Municipality has moderate levels of inadequate sanitation as 46.8% of households make use of a pit latrine (VIP) and 5.3% of all households do not have access to any sanitation facilities (see Figure 5-46). This means that effectively 52% of households do not have access to adequate sanitation facilities. Figure 5-47 illustrates that spatially the lack of access to sanitation services is mostly found Lephalale rural areas. Whereas the majority of households located in urban areas have access to a flush toilet connected to an existing sewerage system.

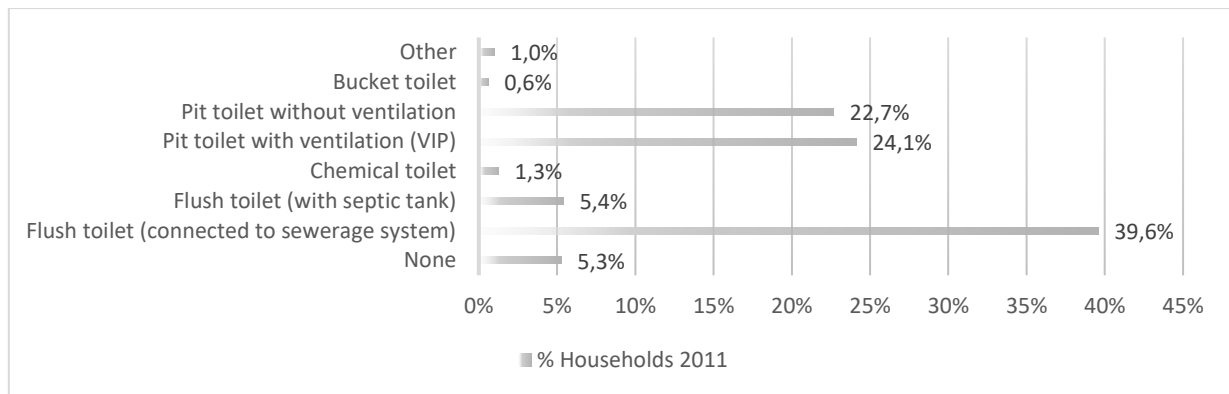


Figure 5-46: Lephalale % of household access to sanitation (2011)

Source: Stats SA (2011)

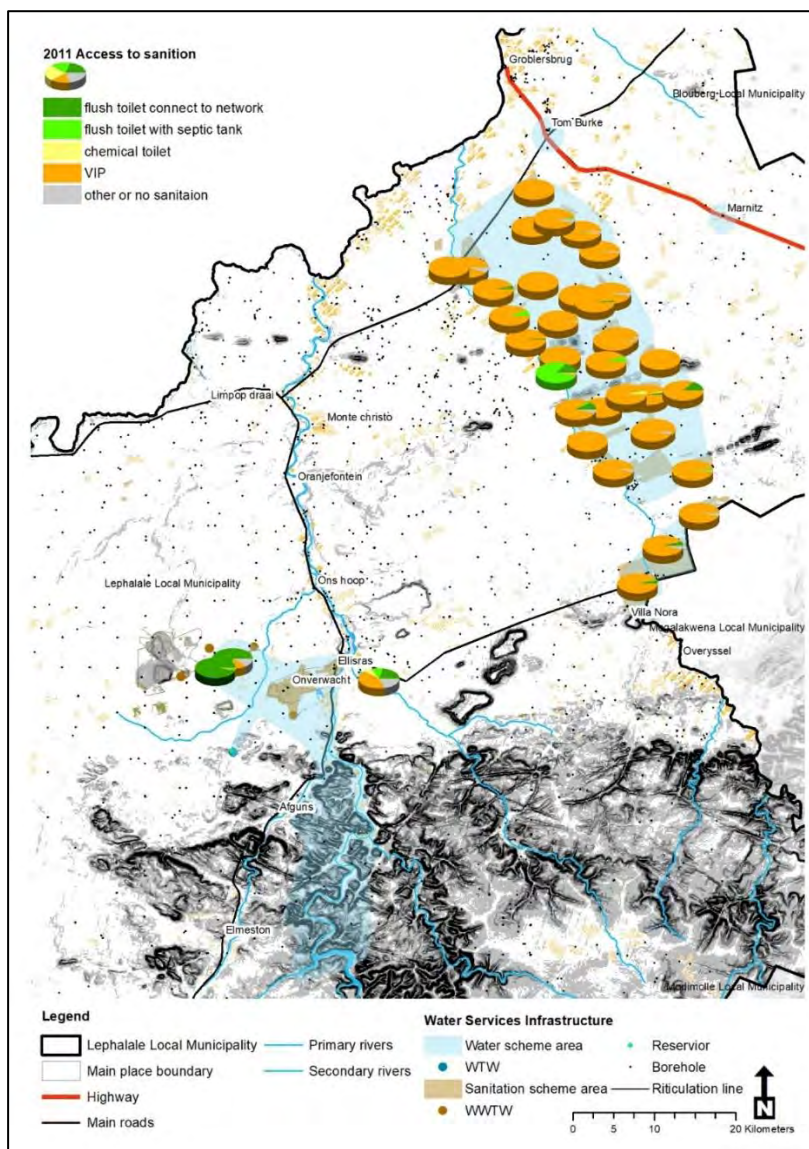


Figure 5-47: Lephalale % of household access to sanitation (2011) by subplace

Source: Own Construction (2018) based on Stats SA (2011)

Regarding water services affordability, according to the annual household income distribution by Geo-type, the majority of poor households reside in the Municipality's rural area (see Figure 5-48). This is a typical settlement trend in most of South Africa's municipalities. Despite the fact that most of these households will be unable to pay water services, providing fixed services to rural settlements is also costly and require high levels of energy input.

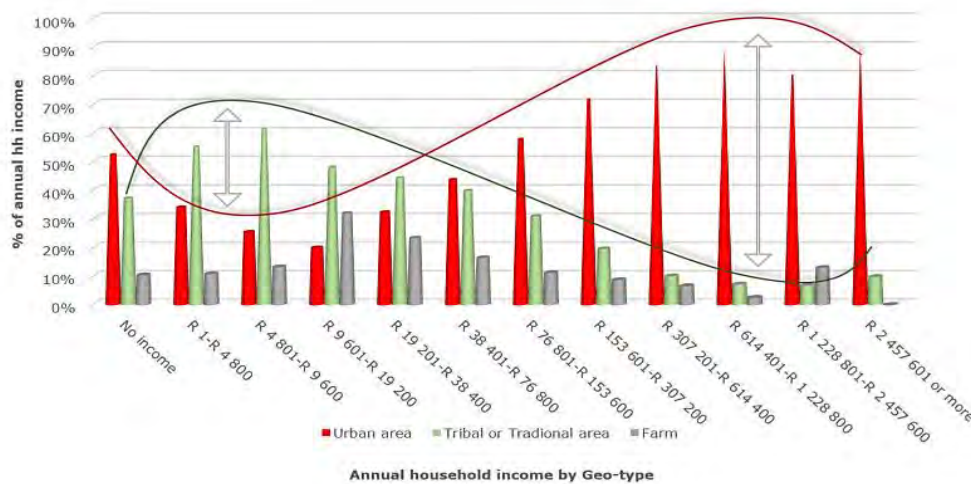


Figure 5-48: Lephalale % of annual household income by geo-type

Source: Own Construction (2018) based on Stats SA (2011)

By comparing the level of access to household services with annual household income, it was found that 32.43% of households earning less than R 19 201/a have access to water services that is above their affordability levels, most likely using more water than the official Department's planning allocation of 60 l/c/d. As for the opportunities to increase municipal revenue, 9.39% of Lephalale's high-income households have a very low level of access to services or makes use of alternative sources Figure 5-49.

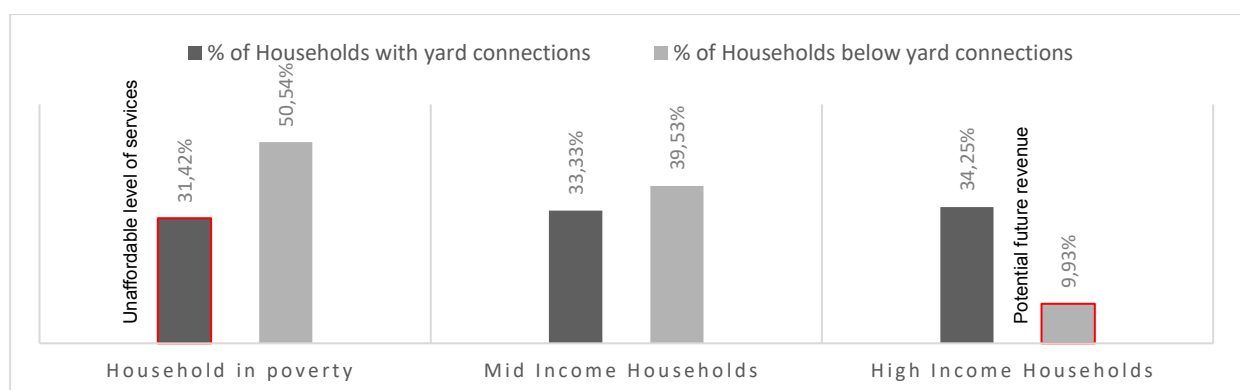


Figure 5-49: Lephalale % of households: Unaffordable levels of water services

Source: Own Construction (2018) based on Stats SA (2011)

According to the spatial information illustrated in Figure 5-50, between 80%-100% of poor households residing in Marapong, Bangalong, Disappointment, Kitty, Thabo Mbeki, Ga-seleka. During a meeting held with Municipal Official in Lephalale, it was confirmed that the high-level of services provided to Thabo-Mbeki was a political decision, to gain votes during the annual council elections.

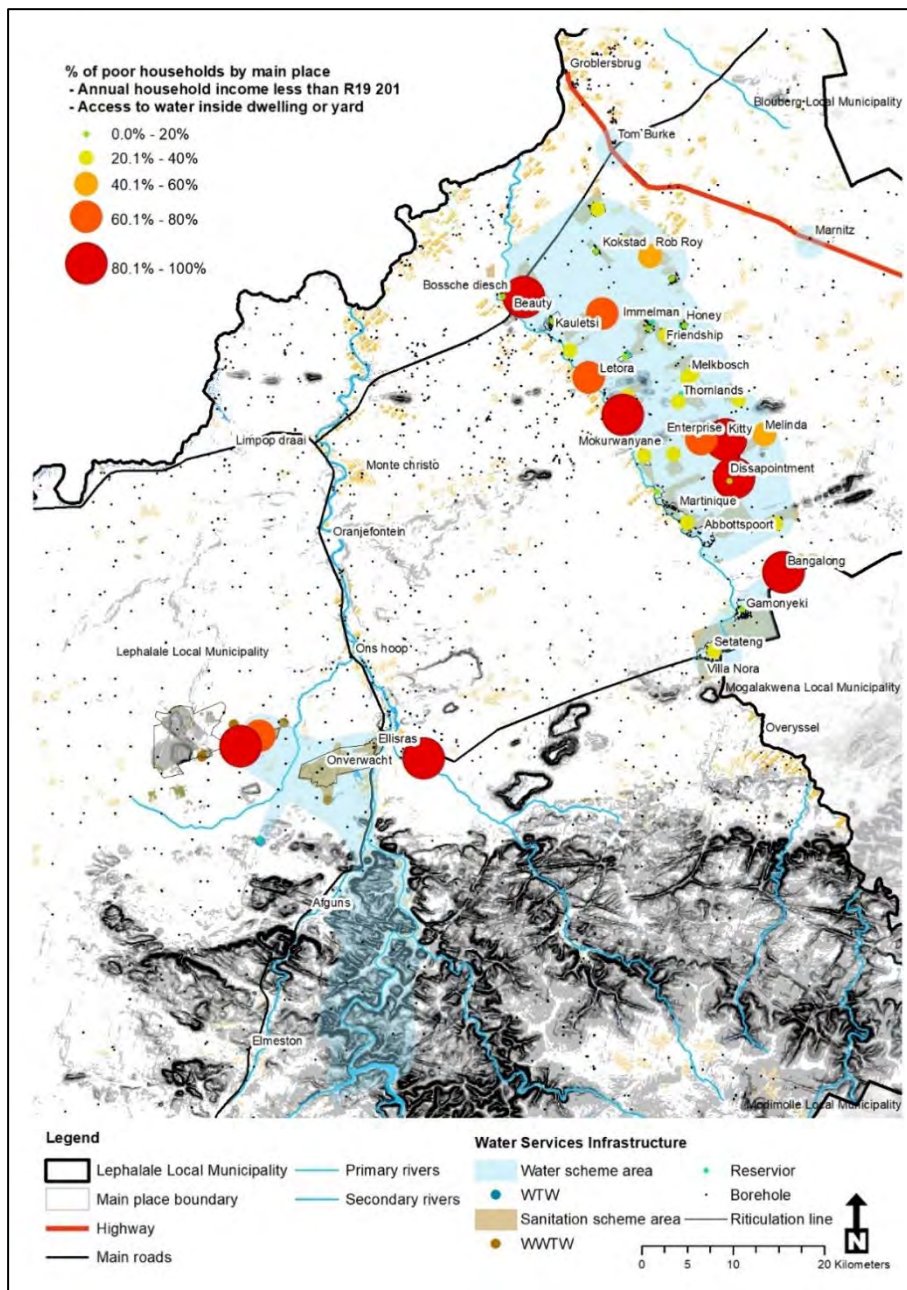


Figure 5-50: Lephalale % of households: Unaffordable levels of water services by subplace

Source: Own Construction (2018) based on Stats SA (2011)

In terms of household affordability to sanitation services, due to the high percentage of households that have access to a low level of services. The corresponding affordability analysis also indicate that only in Marapong does poor households have access to a very high and unaffordable level of sanitation services. As for the rest of the municipality, the level of services provided is an appropriate response to the household affordability ratio (see Figure 5-51).

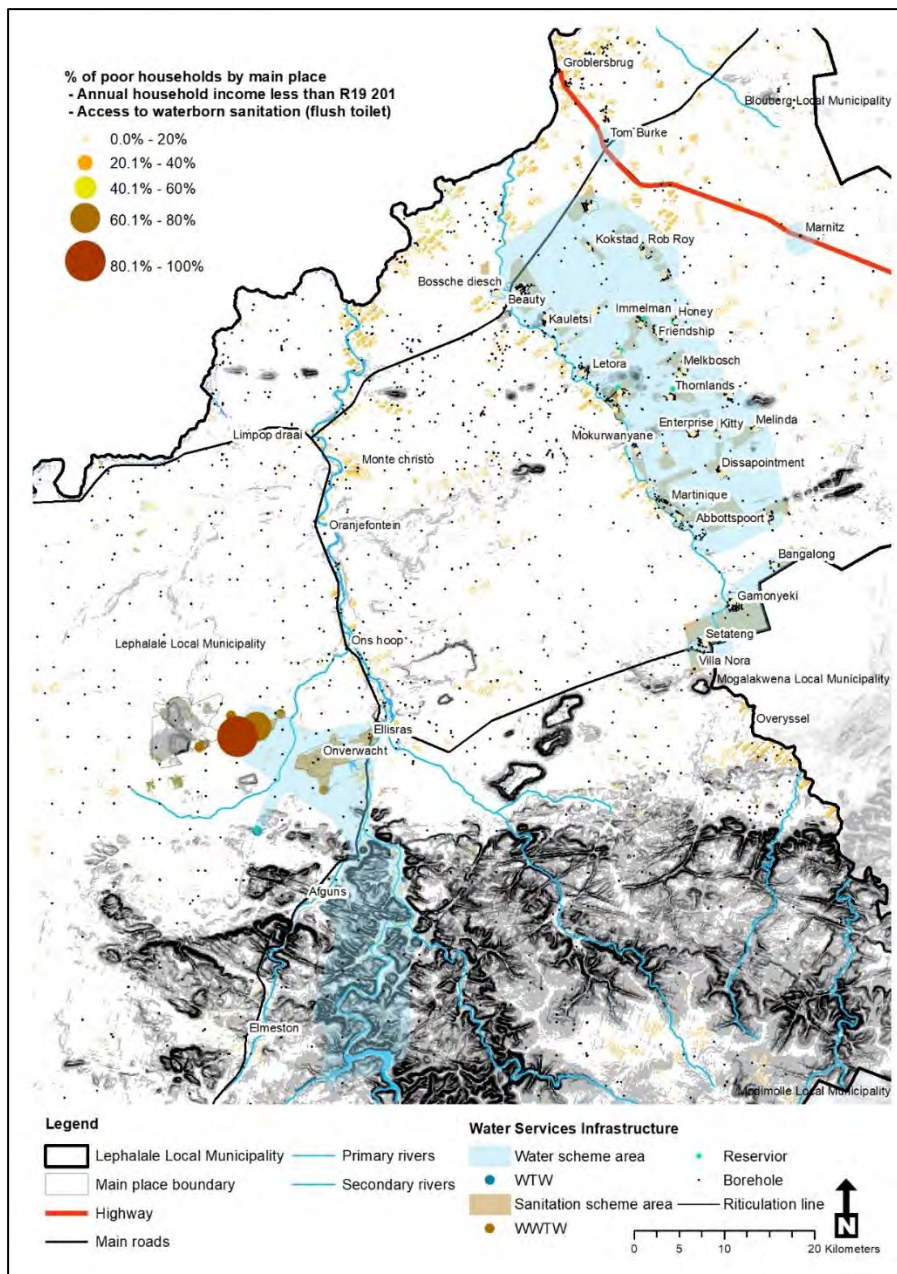


Figure 5-51: Lephalale % of households: Unaffordable levels of sanitation services by subplace

Source: Own Construction (2018) based on Stats SA (2011)

Lephalale Local Municipality's existing SDF should be credited for providing a good analysis of existing levels and access to water services throughout the municipality. It also listed a number of water-related projects as identified in the IDP which includes a plan to increase the Zeeland water storage capacity by constructing additional 3 reservoirs on proposed sites; construction of new pipeline by creating a split from the Onverwacht/ Lephalale CBD supply line; and increasing the capacity of some existing bulk distribution water pipelines to cater for the increasing water demand. The existing SDF also made proposals for future water services as per provincial spatial rational. It states that in:

3. Ellisras/Onverwacht – in general, piped water inside dwellings
4. Marapong – in general, yard connections.
5. Rural Focus Area – yard connections or standpipes within 200m. In some of the formal areas (e.g. Thabo Mbeki) water is available inside dwellings

Lephalale's existing SDF also highlighted several challenges related to water services which including despite the Zeeland water treatment plant been upgraded, its capacity will have to be further increased to cope with the increasing demand by domestic, industrial and mining sectors; currently the Zeeland water treatment plant cannot cope with high raw water turbidity and the quality of water is affected; most existing bulk distribution pipelines are operating close to full capacity and hence need upgrading; and despite the industrial area receiving water from the Zeeland water treatment plant, an increased demand for water by proposed industrial developments will put this plant under tremendous pressure and hence alternative or additional water sources will be required.

Lephalala existing SDF noted some challenges with regards to sanitation services which includes that the sewer treatment plants and the sewer lines are operating close to full capacity and will need to be upgraded and that the upgrading of the existing Paarl Sewer Treatment Plant from 10 ml/d to 20 ml/d is critical. Land use schemes, in general, does not deal with levels of services or future services. In this regard, the Lephalale Land Use Scheme also did not address any matters related to levels of services or future services. Furthermore, affordability to services was not addressed in either documents.

5.4.2.3.1.2 Mogalakwena services assessment: Potable water and sanitation services

Mogalakwena Local Municipality has one registered Water Services Provider, Lepelle Water Board which operates the Doorndraai and Mahwelereng WTW. In 2012, Doorndraai WTW served 125 137 people with an average daily consumption of 95.89 (l/p/d) and Mahwelereng served 36 522 people with an average daily consumption of 54.76 (l/p/d).

Between 2010 and 2011, the Municipalities Blue drop rating rocketed from 47% to 78% and was amended for their significant improvement in the management of drinking water quality in 2011 (DWS, 2014). Unfortunately, the rating declined to 60% in 2014 as the chemical quality of the water did not comply with the excellence requirements of the South African National Standard for drinking water (SANS 241).

Nevertheless, since 2001 the percentage of households with access to piped water inside their dwellings in Mogalakwena increased from 8.7% to 20,2% in 2011 (Stats SA, 2011). In terms of household access to water source, the 2011 census data reports that 69,22% of Mogalakwena's households received their main source of water through the regional/local water scheme. 17,49% Of all households relied on groundwater as their main sources provided by local boreholes; 3.39% access natural resources as their main source for domestic water use. Only 0.64% of households used rainwater tanks (see Figure 5-52). Figure 5-54 the percentage of Mogalakwena's households with access to their main source of water.

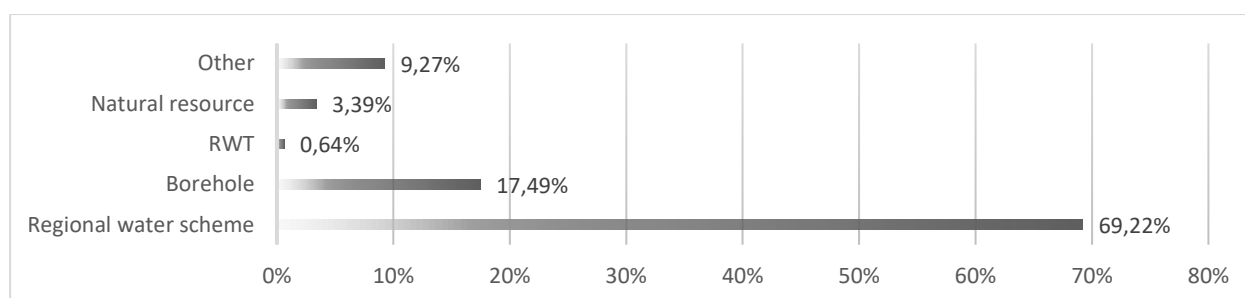


Figure 5-52: Mogalakwena % of households access to main water source

Source: Own Construction (2018) based on Stats SA (2011)

In terms of water supply services, a suitable (RDP) standard of water supply is to have access to piped water either inside a dwelling/yard or at least within 200 metres of the dwelling. According to the 2011 census data, 83.1% of the Mogalakwena's households have access to piped water which includes the sum total of households with piped water inside dwelling/institution, piped water inside yard and piped water on community stand: distance less than 200m from dwelling/institution.

Of this 83.1%, only 20.2% of the households have piped water inside their dwelling (see Figure 5-53). In terms of services backlog (lower than RDP national standard), 16.9% of all households in Mogalakwena only has access to a service lower than basic RDP level of services. Figure 5-55 shows the percentage of household access to piped water in 2011.

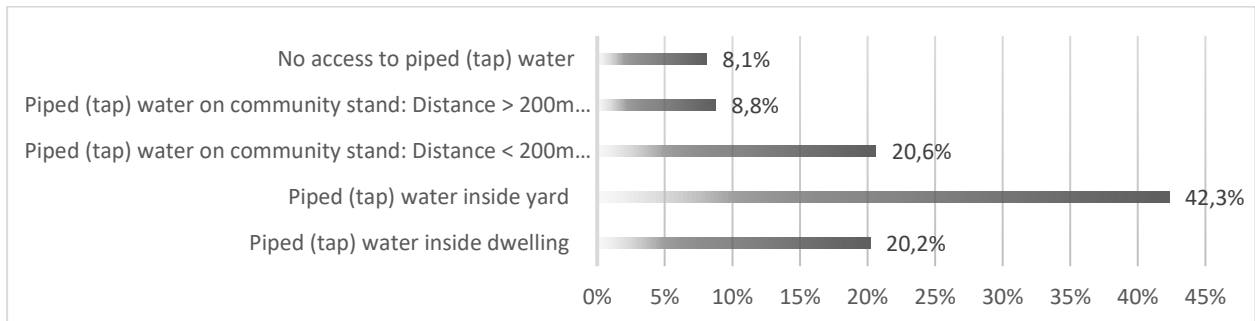


Figure 5-53: Mogalakwena % of household access to main water source

Source: Own Construction (2018) based on Stats SA (2011)

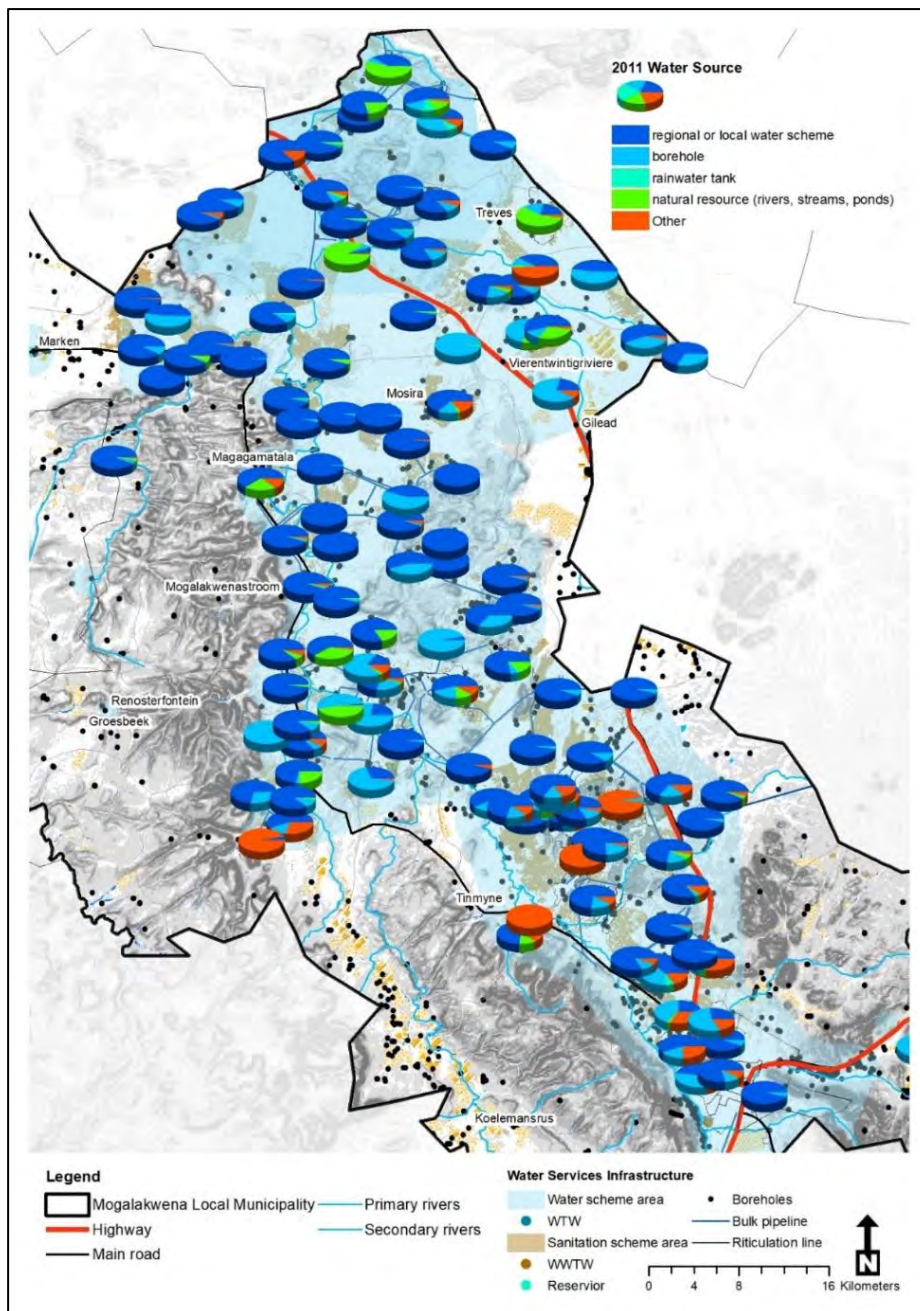


Figure 5-54: Mogalakwena % of household access to main water source by subplace
Source: Own Construction (2018) based on Stats SA (2011)

As mentioned in Section 4.2.2.2, the DWS provides water services information that differentiates between the access to water infrastructure and access to reliable supply. According to Table 5-37, despite the fact that 82,38% of Mogalakwena's urban population has access to piped water, only 67,22% of the population have a reliable supply. A similar situation is found in the rural areas where 82,41% of the population has access to piped water but only 67,24% of the population has access to a reliable supply.

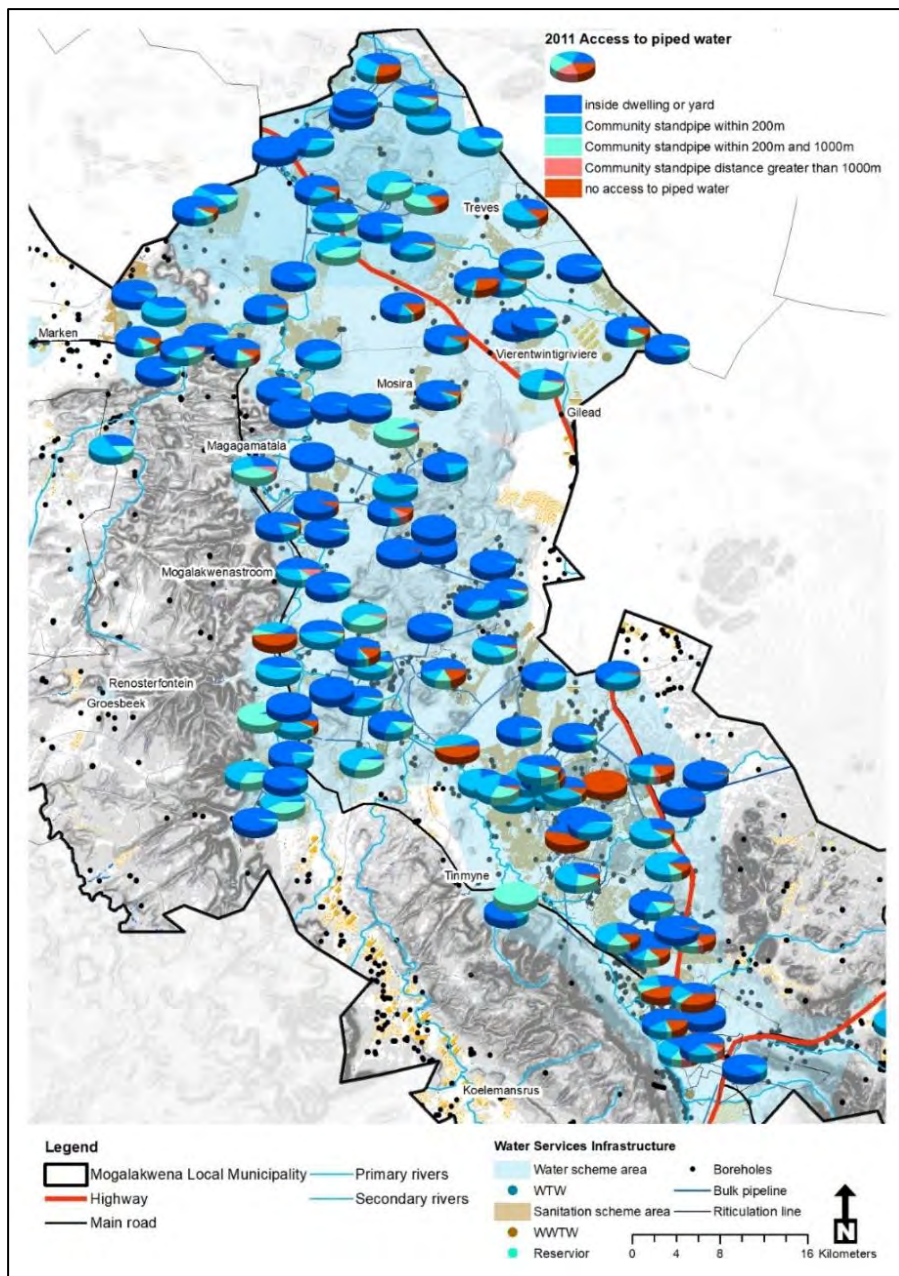


Figure 5-55: Mogalakwena % of household access to piped water by subplace

Source: Own Construction (2018) based on Stats SA (2011)

In both urban and rural areas, almost 30% of the population suffer from the non-reliable water supply. The exact spatial location on where this non-reliable supply is taking place is undetermined.

Table 5-37: Mogalakwena reliable water supply 2017

Reliable water supply 2017	Urban Population	Rural Population
Mogalakwena Local Municipality Population with access to water	82.38%	82.41%
Mogalakwena Local Municipality Pop with NO water	17.62%	17.59%
Mogalakwena Local Municipality Pop with reliability supply	67.22%	67.24%
Mogalakwena Local Municipality Pop with non-reliability supply	32.78%	32.76%

Source: DWS (2017)

Figure 5-56 shows the percentage of household access to piped water in 2011.

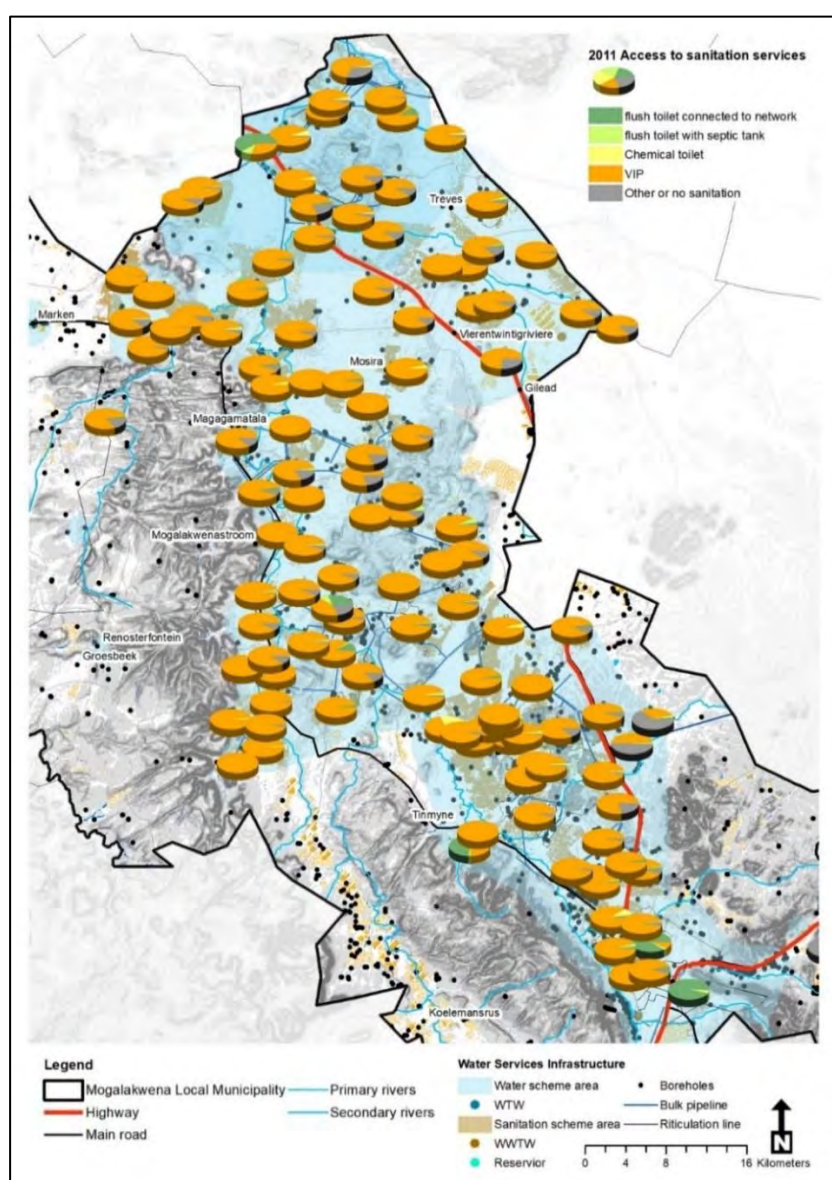


Figure 5-56: Mogalakwena % of household access to sanitation services by subplace

Source: Own Construction (2018) based on Stats SA (2011)

Regarding water services affordability, Mogalakwena has almost twice as many households (83 604 households) as Lephalale residing within its borders. Unfortunately, with this vast number of households, the municipality also has the highest percentage (11.2%) of households that are considered to be "multidimensionally poor". This is a major concern for the municipality as these households dependent on social grants and free basic service. According to Stats SA 2011 data, the majority of Mogalakwena's poor people reside within the rural areas of the municipality as per the income distribution by geo-type illustrates (See Figure 5-57).

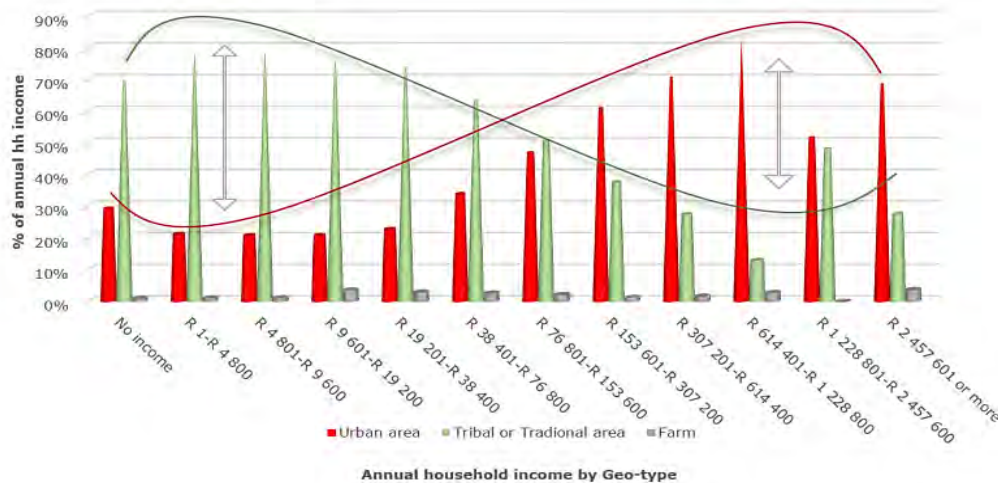


Figure 5-57: Mogalakwena annual household income by geo-type

Source: Own Construction (2018) based on Stats SA (2011)

Although the income by geo-type reveals a similar trend in both municipalities, when comparing the two figures, the gap between urban-rural income levels is significantly greater in Lephalale's higher income categories, meaning that there are far wealthier urban dwellers than in the rural areas compared to Mogalakwena local municipality. By comparing the level of access to household services with the household annual income it was found that 56,96% of households earning less than R 19 201/a have access to water services that are above their affordability levels and they probably use more water than the official Department's planning allocation of 60 l/c/d. There is however scope for the municipality to increase its revenue by a potential 18,46% if they provide a higher level of services to higher income households, see Figure 5-58 and Figure 5-59.

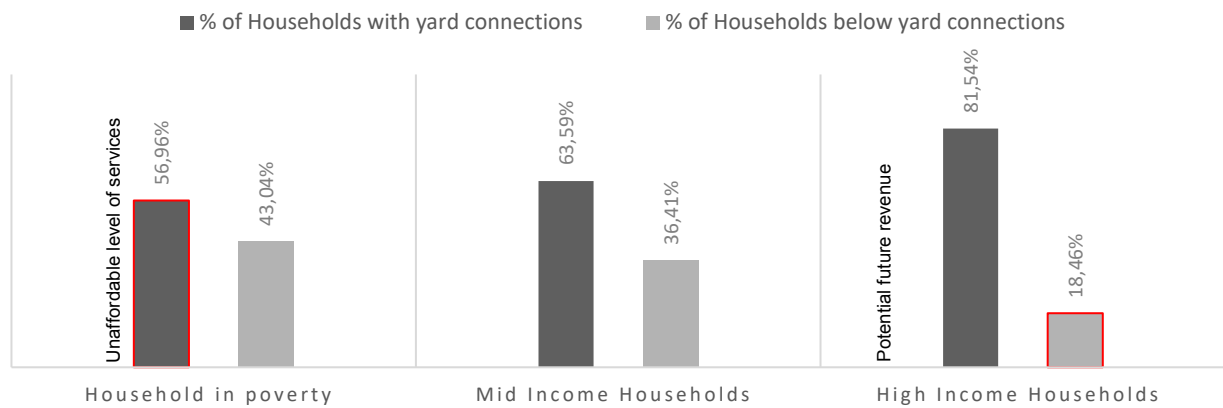


Figure 5-58: Mogalakwena % of households: Unaffordable levels of water services

Source: Own Construction (2018) based on Stats SA (2011)

Figure 5-59 provides a clear illustration of the spatial location of subplaces where between 80%-100% of all households have access to unaffordable high levels of access to piped water.

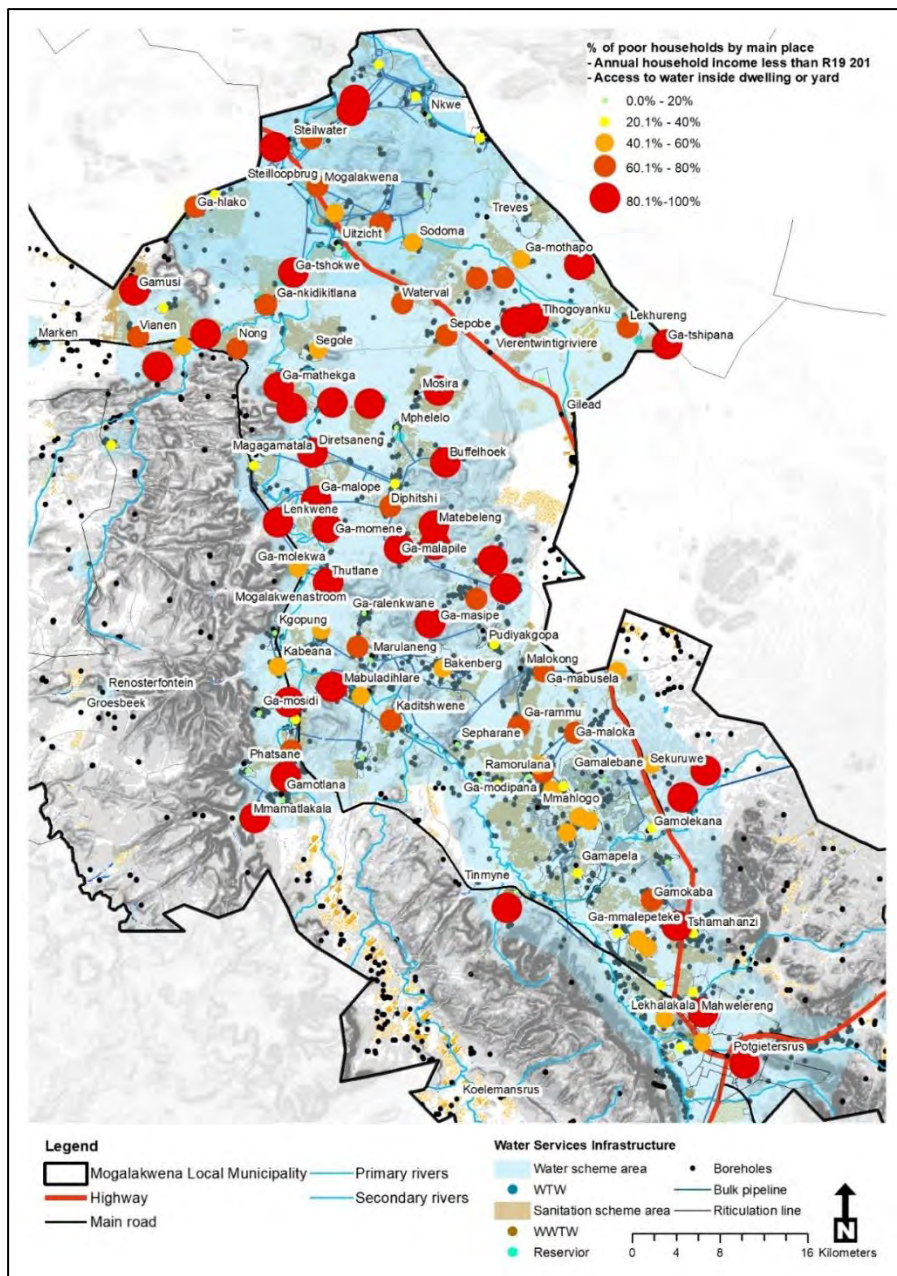


Figure 5-59: Mogalakwena % of households: Unaffordable levels of water services by subplace

Source: Own Construction (2018) based on Stats SA (2011)

Figure 5-60 provides a clear illustration that access to unaffordable high levels of sanitation is not a concern for the municipality.

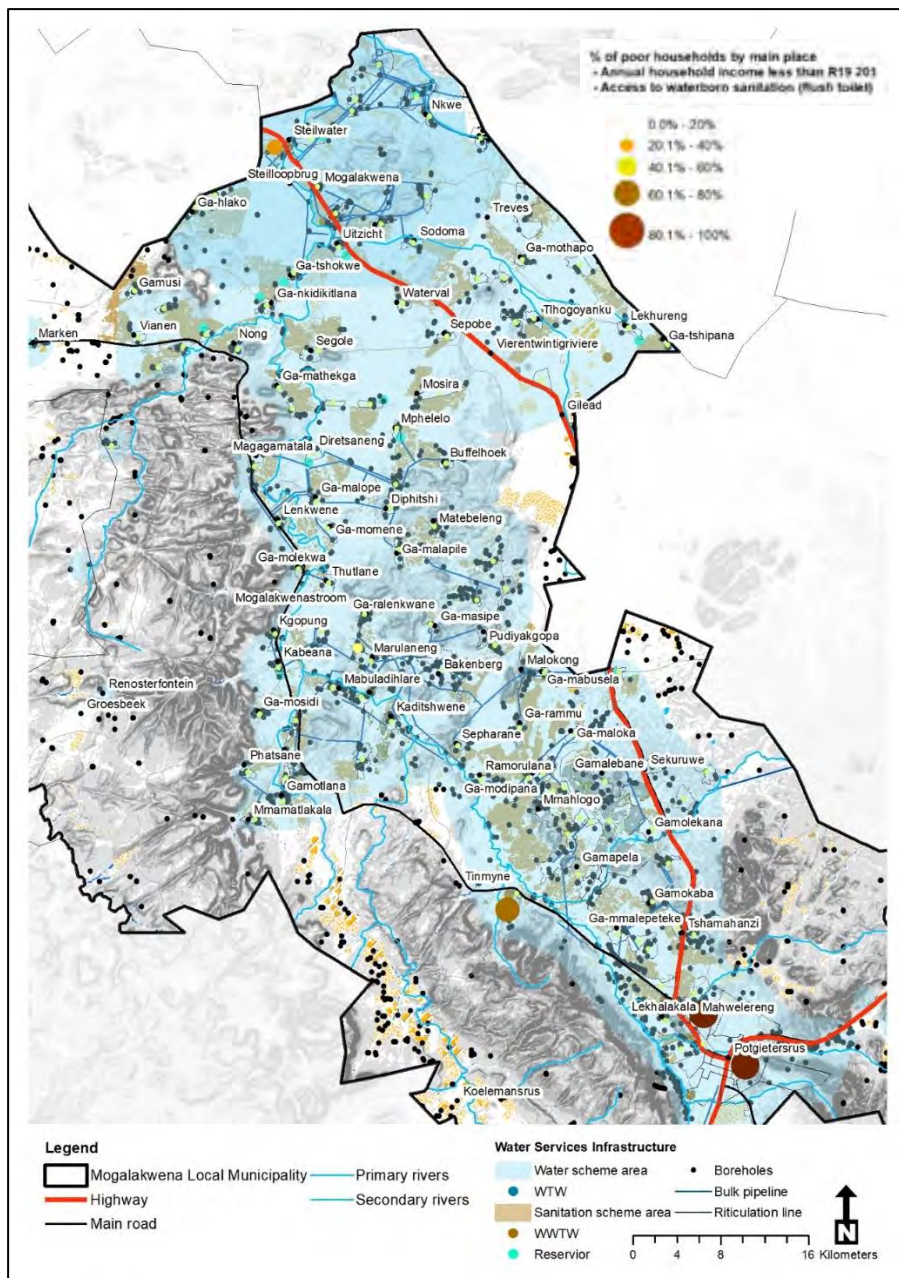


Figure 5-60: Mogalakwena % of households: Unaffordable levels sanitation services by subplace

Source: Own Construction (2018) based on Stats SA (2011)

Mogalakwena existing SDF also reports on household access to services. However, it does not mention anything with regards to backlog in services nor does the SDF mention anything about household affordability to services.

5.4.2.3.1.3 Services assessment: Key findings and conclusion

The evidence based spatial analysis revealed that in both municipalities the dependency on water through regional services as their main source is very high (above 70%). In several settlements, households utilise groundwater resource through boreholes, however the spatial data also indicated that several of these boreholes might extract groundwater resources of poor quality, which may lead to health threats. The spatial data should therefore be used to inform future levels of water services – while land use scheme should be used to implement buffer zone around boreholes to prevent contamination of groundwater resource. To date, the use of boreholes or anything other than piped water remains frowned upon. In terms of water sensitive development, these resources should be utilised more often, replacing the need for extensive bulk water distribution network. Regarding water supply and sanitation services, the evidence based spatial analysis identified several settlements where backlog in services remains high. As noted in Section 4.3.2, in poorly services settlements, municipalities should consider a leap-frog approach to services delivery. This is also implied by the 2006 NSDP, stating that fixed infrastructure investment must be prioritised in areas that display economic growth. Whereas, areas displaying limited economic potential identify alternative or off-grid solutions to infrastructure. As for services affordability, unsustainable levels of access to services was found throughout both municipalities (see discussion in Section 3.5.4). Household access to unaffordable high levels of services is often a result of political promises – to gain votes during election period. Though well intended, the financial strain of such high level of services can often result in an underinvestment in operations and maintenance of infrastructure.

As for the SDF, directing growth towards nodes or areas where the existing infrastructure networks can increase its carrying capacity can result in reduced volume of UARL throughout the water distribution network.

5.4.2.3.2 Future water needs

Planning for future growth (the where and who) is one of the key functions of an SDF. This has become a detailed study of its own in the field of urban and regional planning. The bulk of models used in South Africa is GIS-based or linked to spreadsheets that contain demographic or housing projections. Most systems rely on remote sensing which uses historic land cover data to predict change. Conducting an in-depth modelling exercise to predict future growth is beyond the scope of this study. However, it is of utmost importance to highlight the link between future housing demand which is a spatial planning function and the implication thereof on future water demand which is mainly the Water Services Authority or Water Services Providers responsibility.

Furthermore, predicting the future water demand for any given municipality should be addressed in the municipal Water Services Development Plan as per Section 13(h) of the Water Service Act (also see discussion in Section 4.2.3.1). Since the WSDP is non-existing in both municipalities and most likely in many other local municipalities, the data generated in Section 5.4.2.2.1 (Land Use Water Quantity Analysis) combined with historic census household statistics (2001; 2011 and 2011) urban planners can start to equate growth by land use, also referred to as customers (users of water) to additional demand in water. A basic Excel growth projection was used to determine the household growth and future water demand for both Lephalale and Mogalakwena Local Municipality. This demand is not absolute, but only an estimated projected future demand. Key to this analysis, is purely to indicate that if urban planners conduct a detailed study to determine future growth linked to where (space) and who (households, industrial or business), water consumption information can be used to determine future water demand as well.

5.4.2.3.2.1 Lephalale services assessment: Future household water needs

According to the excel population growth model, Lephalale's households are expected to grow by 9 674 additional households in the next 5 years, and 15 592 households over the 10-year planning horizon. Based on Lephalale's average monthly households water consumption of 275 KI (identified in Section 5.4.2.2.1.1), Table 5-38 reveals that within the next 5 years, the monthly households demand for water resource will increase by 310 750 KI, and over the 10-year planning horizon by 4 287 800 KI.

Table 5-38: Lephalale household growth and future water demand

Year	Households	Household Increment	Additional Water required (KI)
2016 (base year)	25 709		
2017	30 607	4 898	1 346 950
2018	31 852	1 245	342 375
2019	33 071	1 219	335 225
2020	34 253	1 182	325 050
2021	35 383	1 130	310 750
2022	36 536	1 153	317 075
2023	37 710	1 174	322 850
2024	38 904	1 194	328 350
2025	40 118	1 214	333 850
2026	41 301	1 183	325 325
10-year planning horizon		15 592	4 287 800

Source: Own construction (2018) based on Stats SA (2001; 2011; 2016)

Lephalale's existing SDF should be commended for its detailed analysis on future growth projection. Not only does the SDF provide information with regards to future household, it also provided growth projections for all other land uses and their projected need for land (space). The projected household figures are exactly the same as the projected household figure in Table 5-38 as the same data was used to conduct the analysis. However, the 2017 Lephalale Spatial Development Framework did not address the future demand for water resources.

5.4.2.3.2.2 Mogalakwena services assessment: Future household water needs

Households in Mogalakwena Local Municipality is expected to grow by 4 527 additional households in the next 5 years, and 9 299 households over the next 10-year planning horizon. Based on Mogalakwena's average monthly households water consumption of 32.01 KI (identified in Section 5.4.2.2.1.2), Table 5-39 reveals that within the next 5 years, the monthly households demand for water resource will increase by 54 325 KI and over the 10-year planning horizon by 111 593 KI.

Table 5-39: Lephalale household growth and future water demand

Year	Households	Additional Households	Additional Water required (KI)
2016 (base year)	83 604		
2017	84 490	886	10 637
2018	85 386	1 782	21 387
2019	86 292	2 688	32 251
2020	87 206	3 602	43 230
2021	88 131	4 527	54 325
2022	89 066	5 462	65 539
2023	90 010	6 406	76 871
2024	90 964	7 360	88 323
2025	91 929	8 325	99 896
2026	92 903	9 299	111 593

Source: Own construction (2018) based on Stats SA (2001; 2011; 2016)

Mogalakwena's existing SDF also provides an excel based households growth projection. However, the figures differ slightly from the projected growth as indicated in Table 5-39. Reasons may be that Mogalakwena's 2009 Spatial Development Framework did have 2011 or 2016 household statistics. However, the existing SDF did not make any mentioning of the impact of the projected households on water demand.

5.4.2.3.2.3 Future Water Needs: Key findings and conclusion

Although the analysis provided in Section 5.4.2.3.2 was not as comprehensive as the previous sections, it does provide an indication that WSSP can give effect to planning for future water resource demand. It should be kept in mind that the demand will be influenced by the level of service provided, as discussed in Section 5.4.2.3.1. Yet, this evidence based analysis already provides the spatial planner, and therefore, the municipality with an indication of what the future demand for water may be.

There is scope for future research to develop an in-depth methodology to synchronize all of the previous assessments into one consolidate Water Sensitive Growth Model - to provide a better and more accurate understanding as to where and by whom water future water demand will take place.

This section concludes Phase 2 of the empirical investigation. Section 5.5 to follow, provides all relevant findings of Phase 3 of the empirical investigation.

5.5 Empirical Investigation Phase 3: Stakeholder engagement

The third phase of this study's empirical investigation was informed by several stakeholder engagements held in association with the WRC research Project no. K5/2587. Section 5.5.1 provides a synopsis of process, key inputs and findings of each Reference Group Meeting.

5.5.1 WRC Reference group meetings

As mentioned in Section 1.7, the WRC embarked on a new research project to bring WSUD, as defined and envisioned by the WSUD Framework, into the larger municipal planning environment. Based on this study's aims and objectives, the WRC awarded a new research project (K5/2587) entitled, 'Securing water sustainability through innovative spatial planning and land use management tools: Case study of two local municipalities in 2016'. During 2016 and 2019, five semi-structured reference group meetings were held with leaders in the field of land, water and environmental resource planning and management. Table 1-1 in Chapter 1, lists the names of the WRC Project No. K5/2587 Reference Group Members, their positions and expertise in their respected fields and their contact details. K5/2587 produced seven research documents, each of which was presented, discussed and workshopped with the reference group members. The meeting was recorded electronically and can be provided on request. However, the duration of each meeting is no less that more than 6 hours each.

- The first Reference Group Meeting was held on the 29th July 2016, at the Marumati Building, 491 Eighteenth Avenue, Rietfontein, Pretoria. This was the inaugural meeting where the research proposal (inception report) and the aims, objective and methodology of Research Project K5/2587 (as contained in Chapter 1 of this study) were reflected on . The meeting also served to inform all Reference Group Members unfamiliar to the SPLUMA – on the new legislative requirements of the act and how this study envisions the development of water sensitive SDF and Water Sensitive LUS. All Reference Group Members concurred that this study is new and innovative to all fields related to land, water and environmental resource planning.

- The second Reference Group Meeting was held on the 14th February 2017, at the Bloukrans building, 4 Daventry Street, Lynnwood Manor, Pretoria. During this meeting, the literature review was presented. Similar to Chapter 2, 3, and 4 of this study, the literature review focused on “Land and water resources”; “South Africa context specific”; “Freshwater Ecosystems Planning and management”; and “Why Planning” which specifically focused on the requirements of SPLUMA, and how spatial planning and land use management can potentially give effect to achieving WSS. Some of the key comments and inputs of the Reference Group Members that emanated from the reference group meeting include:
 - a lack of resilient design of cities and their urban systems – has made the impact of climate change even more severe in urban areas as most of these areas are not designed to accommodate the impact of climate change;
 - current trends of overgrazing in rural areas, due to a lack of land use management, has led to severe flooding and ground erosion during major storm or climate-related event;
 - concerns were raised about using the phrase “infrastructure”, as infrastructure does not necessarily mean that there will be water. it was therefore suggested that the term “ water services” should rather be used;
 - comments were made about national legislation which led to a developmental state where local municipalities focus so hard on services delivery driven by the “needs document” which is the municipal idp, efforts to implement “sustainable services delivery” is often afterthought, once conventional infrastructure is physical and hydrological integrity has been compromised;

- concerns were highlighted about south africa's migration pattern, where several municipalities (e.g. ethekwinini metropolitan municipality) are experiencing de-urbanisation causing severe infrastructure and services delivery challenges;
 - concerns about poor agricultural practices on water resources where highlighted; and,
 - it was suggested that more focus should be placed on the impact of land uses on water resources quality.
- The third Reference Group Meeting was held on the 30th of September 2017, at the Bloukrans building, 4 Daventry Street, Lynnwood Manor, Pretoria. This was an informal meeting between the Researcher, and two key stakeholders, Mr Fourie and Mr Bhagwan. The meeting discussed the issue of availability of spatial data on land, water and environmental resources. Furthermore, two of the integrated spatial analysis methodologies were introduced at this meeting: the Land Use Water Quantity Impact model and the Rainwater Harvesting Potential Model. Key comments and inputs which emanated from the discussions:
 - Land Use Water Quantity Impact model, the volume of individual land use by water consumption was questioned as the findings seemed to have be unrealistically high (in the case of Lephalale). After a thorough investigation of the spatial data and the billing data, both stakeholders confirmed that the methodology, data and findings were in order.
 - Rainwater Harvesting Potential Model, after furrow testing, the methodology designed to calculate the rainwater harvesting potential of a city was confirmed to be correct by both key stakeholders.
 - The fourth Reference Group Meeting was held on the 15th of August 2018 at the Bloukrans building, 4 Daventry Street, Lynnwood Manor, Pretoria. During this meeting, the literature review was presented. The meeting served to provide inputs into "Deliverable 4 - Water Sensitive Spatial Development Framework: Guideline". Similar to that of Chapter 4 and 5 of this study, the Deliverable 4 focused on "the concept of Water Sensitive Cities"; the "SDF development process"; what sort of "Water Sensitive Spatial Proposals" can be developed; and "how can municipalities give effect to such spatial proposals". The discussions during this meeting provided valuable inputs in the final framework for WSSP and the guideline document to compile water sensitive tools.

- As for the 5 Deliverable – Guidelines to compile water sensitive land use scheme, no formal reference group meeting was held, yet the document was circulated to all reference group members for comments. This deliverable was met to be included as an additional chapter in Deliverable 4 – adding the LUS component to the document, creating a consolidated guideline for WSSP. A semi-structured meeting was held with one of the key stakeholders, to discuss the methodology, calculations and findings of the following spatial analysis models and assessments:
 - Land use Water Quality Impact Model (adopted from Macfarlane *et al.* (2014))
 - Density Water Loss Model (workshopped and consulted by various engineers)
 - An all other Macroscale biodiversity assessments (consulted with DAFF)
- The final Reference Group Meeting was held on the 29th of January 2019, at the Bloukrans building, 4 Daventry Street, Lynnwood Manor. Several new members attended the meeting as they were showed interests in the final finding of the study. The final meeting focused on the Deliverable 6 - Framework towards Water Sensitive Spatial Planning and Land Use Management, and Deliverable 7 – Guideline on compiling water sensitive spatial plans. Similar to what is presented in Chapter 7 of this study. Key comments and inputs from the Reference Group Members that emanated from the final reference group meeting:
 - The study is considered “Ground-breaking and first of its kind”
 - Reference group members expressed how important the findings of this study will be for sustainable groundwater management as this is almost always excluded from spatial planning and land use management documents.

Since the final Reference Group Meeting, the researcher was appointed by the WRC to provide nationwide training for local municipalities on how to achieve WSSP. Once again, this study reflects on, and provides only a synopsis of the WRC deliverable linked to the WRC Research Project K5/2587.

This section concludes all the phases of the empirical investigation. Section 5.6 to follow concludes the empirical investigation.

5.6 Conclusion

Throughout this Chapter, conclusions were provided after each phase of empirical investigation. Thus, this section provides a high-level overview of each phase.

In conclusion to the three phases of this study's empirical investigation, it is evident that land use has both quantitative and qualitative impact on water resources, which is currently not being addresses in spatial planning and land use management documents as revealed in the phase 1.2 of the empirical investigation.

The fact that legislation, policies and plans engaged with land, water and environmental resources planning and management must align and give effect to one another was highlighted throughout phase 2.1 of the empirical investigation. However, the thematic self-evaluation assessment provided in phase 2.1 also found the high-level national targets and objective barely ever makes its way down to localised implementation. As a result, the integrated hierarchy of strategic and regulatory planning documents, stand in isolation from each other.

Nevertheless, phase 2.2 of the empirical investigation proved that integrated systematic analysis of spatial dimensions (population distribution, land use, water and environmental resources) can use to give effect to national and provincial governments development targets (e.g. NDP target-2030: reduce urban water demand by 15% below business-and-usual). Furthermore, new methodologies accompanied by uniquely structured aims and objective for addressing water sensitivity can assist both the theory and practice of spatial planning and land use management in securing future water resources. In essence, the evidence based spatial planning and land use management tools can and should be used to reduce the quantitative impact on water resources and improve the quality of water resources.

Based on the inputs of experts in the field of land, water and environmental resources planning (as reflected on in phase 3 of the empirical investigation) – this study concludes that the literature review and empirical study addressed the concept of water sensitivity within the broader legislative framework for spatial planning and land use management and provided innovative and evidence based methods to inform the development of spatial planning tools.

CHAPTER 6 CONCLUSION

6.1 Introduction

In this chapter, the findings of this study across the previous chapters where a literature review and empirical study was undertaken - are synthesized to understand how these various aspects relate to one another and have informed the conclusions and recommendations of this study.

As mentioned throughout this thesis, Parliament enacted a new spatial planning and land use management act, the SPLUMA in 2015. Unlike South Africa's previous planning legislations, SPLUMA clearly defines the purpose and content of what a local municipal SDF and LUS must aim to address. With this new Act in place, opportunity for change is at its best.

Thus, this study set out to develop innovative and evidence based tools through which spatial planning and land use management practices can secure future water resources to give effect to the primary research question as articulated Section 1.3:

“How can water sustainability be secured through innovative and evidence based spatial planning and land use management practices?”

In addressing the primary research question, several secondary questions and research objectives were established. The following section will address each secondary question by providing references as to where this study gave effect to such question, to prove that the study answered the question and that the research objectives were met.

6.2 The interdepend relationship

Secondary Research Question 1: What is the relationship between land and water resources and in what way have anthropological activities affected water resource quality and quantity on a global scale?

Part 1

Part 2

Chapter 2 mainly sought to answer the above secondary research question. The first part (Part 1) of the research question was largely explored and addressed in Section 2.2, providing literature which explains the closed-loop system of the natural hydrological cycling – where land and water is embedded in an integrated and interdependent relationship. One of the key features of this interdependent relationship is the purification proses which takes place once precipitation (water)

infiltrates into the soil (land) and becomes soil moisture or groundwater (Wilhelmson & Ramamurthy, 2010; Davis & De Wiest 1966:460). If not infiltrated, precipitation will result in surface runoff that seeps into streams, rivers, wetlands, estuaries and oceans, where it once again evaporates, condenses, forming clouds and releasing precipitation – making water a natural renewable resource (Hairston & Stribling, 2001:2; CapeNature, 2014). The literature makes it evident that natural landscapes have an important and irreplaceable function in the natural hydrological cycle which includes purification, recharge and setting the pathway to larger water bodies. Land also depend on water resources to remain productive and in good ecological condition. While the relationship between land and water resources was proved to be interdependent, other factors such as natural climate zones were found to influence the stability of the relationship, as explored in the latter part of Section 182.2. In essence, the land-water resource relationship is weakened by long dry periods typically associated with Climate Zone B in which South Africa is located as mentioned in Section 4.3.1.

The second part (Part 2) of the research question was largely explored and addressed throughout the remainder of Chapter 2 which focused on anthropologic interferences in Earth's natural system and natural resources availability. Throughout Section 2.3, the impact of population growth, industrial development and urbanisation were deliberated on in a coincided manner to the evolution of water and wastewater distribution systems, revealing an (i) quantitative and (ii) qualitative impact on water resource.

The (i) quantitative impact was found mainly to relate to the physical consumption of water resources which increased significantly during the 1900s, as modern water distribution network made water resources more readily available for growing cities.

The quantitative impact of anthropological activities on water resources were also explored in the empirical investigation, Section 5.4.2.1, which proved that all and use (anthropological interference) has a quantitative impact on water resources. In the empirical investigation, Section 5.4.2.1 also proved that settlement densities have a quantitative impact on water resources as higher density developments were proven to have a reduced UARL throughout its water distribution network - (see: Density Water Loss Model). The Macroscale Water Quality and Quantity Analysis provided in Section 5.4.1.2 of the empirical investigation, noted that in both case study, the cumulative neutralised streamflow reduces by more the half its volume when land use information is included. Chapter 4, Section 4.3.2 also provided an overview of South Africa's water resource demand by economic sector, revealing the quantitative impact of anthropological interferences on a local scale.

The (ii) qualitative impact, was found mainly to relate to the impact of land-cover change to accommodate anthropological land use, and through the volume of wastewater generated - also seen as the aftermath of the quantitative impact. This was further explored in the empirical investigation, Section 5.4.2.2.2, which provided spatial evidence that all land use has a water quality threat rating, causing a negative qualitative impact on water resources. Section 5.4.2.1.3 also provided spatial evidence that unregulated land use change has led to the destruction of valuable natural landscapes or ecological infrastructure which according to the first part of this research question, is vital for sustaining a healthy land-water resources relationship. Chapter 4, Section 4.2.1.1 – Section 4.2.1.3 highlighted some of South Africa water resource challenges, more specifically the state rivers, wetlands and estuaries which according to multiple sources has severely been impacted by anthropological interferences (e.g. discharge of untreated wastewater; and, physically replacing landscapes of ecological importance with impervious surfaces and agricultural activities).

In conclusion to the secondary research question, Section 2.4 provided a glimpse into future uncertainties – where anthropological activities will continue to impact water resource quality and quantity, if no interventions are implemented. This too was explored in the empirical investigation, Section 5.4.2.3.2 and Section 5.4.2.2.2, proving that in both case studies, water demand is likely to increase, while water quality will most likely deteriorate. Synergising it all, this study concurs that dealing with these issues are more urgent than ever before. Based on the above synthesis, this study aimed to have addressed the following research objective: *“Establish a clear understanding of the interdependent relationship between land, water and environmental resources and the impact of anthropological interferences on future resources”*.

6.3 Hydrosocio contract: Supply - Demand

Secondary Research Question 2: How has South Africa’s hydrosocial contract affected water resource availability and in what way have spatial development trends contributed to South Africa’s status quo?

Part 1

Part 2

Chapter 3 mainly sought to answer the above secondary research question. The answer to the first part of the research question lies within the literature review of South Africa’s spatial development trends and water resources management history - presented in a concise manner throughout Chapter 3. Based on the literature review provided in Chapter 3, South Africa’s hydrosocio contract is broadly defined by three eras’ including (i) the era of industrialisation and urbanisation, (ii) the apartheid era, and (iii) and the era of democracy.

- (i) The era of industrialisation and urbanisation - According to Section 3.2 of the literature review, South Africa's hydrosocio contract started in the early 1600s when the colonisers brought with them Western intellect and introduced the freehold tenure of land and the riparian principle of English-American law. With this, landowners gained all natural-rights that were attached to their land and specifically land alongside rivers (Rowlston (2011:21), prohibiting States control over water resources. In the early 1800s, economic opportunity, mainly related to mining activities in the countries interior, also led to rapid urbanisation and industrialisation. Increased demand for water resources, coupled with endemic dry and low rainfall conditions of the time, soon led to the adoption of a new water law, the Irrigation and Conservation of Waters Act 8 of 1912 (Thompson *et al.*, 2001:12; Republic of South Africa, 1912). Although the Act was a step in the right direction for reducing water demand, the riparian principle remained a central feature of the Act. (Uys, 2008:v; Mackenzie, 2009:443).
- (ii) The apartheid era - the second era of South Africa hydrosocio contract started in the early 1900s when South Africa adopted its first racial legislations the Native Trust and Land Act (Act 18 of 1936) which prohibited any ownership and/or purchase of land by Natives outside the stipulated reserves, formalising the separation of urban White and rural Black areas. As the riparian principle was still enforced by the Irrigation and Conservation of Waters Act 8 of 1912, the perpetuating the discriminatory practice of unequal allocation of water resources continued (Uys, 2008:v; Mackenzie, 2009:443). Section 3.2.2 reports on an unbalanced system where the majority of Black people were pushed to the outskirts of towns where access to infrastructure services was extremely poor vs the predominantly white residential areas which were well laid-out and well-serviced. This high level of access to water services, specificity of the white Afrikaner, increased the demands for the country's limited water resources significantly. Industrial development and economic growth added additional demands. To provided sufficient water to all, the Department of Water Affairs adopted a water resource management approach which primarily aimed to increase supply to meet demand. Large dams and water transfer were constructed during this era, even though information on the long-term environmental consequences were unknown (King et al., 2011:12).
- (iii) The era of democracy - the final era of South Africa hydrosocio contract, as per Chapter 3 started in the early 1990s, when South Africa became a democracy and all citizens were promised equal access to water resources. During this period, Government adopted several new policies and legislation impacting on both land and water resources. These policies and plans were highly influenced by international paradigm shift towards

sustainable development, however, implementation failed to reflect the principle of sustainability as the predominant approach of increasing supply to meet demand continued. Capital investment in bulk fixed infrastructure in previously disadvantaged areas became the norm throughout the country. Though well intended, beneficiaries were unable to pay for this high level of services. This was further explored in Section 5.4.2.3.1 of the empirical investigation which determined the percentage of households unable to pay for their high level of services. This trend still continues today as various national strategies still aim to eradicate access to services backlog – through the conventional way. This statement is based on the fact that despite the numerous policies and strategic plans which South Africa adopted since the dawn of democracy, very limited if any actively pressure the notion to reduce demand in order to meet available supply.

The second part (Part 2) of the research question focuses specifically on historic spatial development trends and the policies that guided planning. Throughout Section 3.2.1, Section 3.2.2 and Section 3.4, the literature review pointed to the fact that spatial planning and land use management was used to give effect to Government socio-political agenda which according to the study is defined by two opposite approaches.

The first socio-political agenda promoted segregated settlement building as discussed throughout Section 3.2.1 and Section 3.2.2 – creating two distinctive settlements, Urban and Rural. Urban areas consisted mainly of well laid-out, well-serviced, tree-lined suburbs, conveniently located close to employment and major urban facilities; while rural settlements were unplanned, had limited access to services and in some areas severely overpopulated.

In terms of spatial planning practices, Section 3.4.3 noted that municipal spatial planning was at the time confined to a highly complex legal environment. Yet, it was also almost always only applicable to urban environments. In rural areas, land use planning was seen as the Chief's responsibility, who had limited knowledge of sustainable land use management practices. This means of spatial planning dominated for almost an entire century in South Africa.

Governments second socio-political agenda focused on promoting integrated settlement building through Agenda 21 development principles as discussed in Section 3.3.4 and Section 3.4.1. However, at the time, integration meant that urban settlements will expand far beyond their existing boundaries – resulting in low density, highly fragmented and sprawling layouts. The impact of this development trend on natural resources was devastating as highlighted throughout Section 3.5 and Section 3.6. Nevertheless, to rectify the wrongs, Parliament promulgated a new Framework Act, the SPLUMA in 2015, setting new requirements and principal for spatial planning

and land use management practices – which is study identified as an opportunity to change the business-as-usual approach to spatial planning and land use management from water wasteful – to water sensitive. Based on the above synthesis, this study aimed to have addressed the following research objective: *“Carry out a hydrosocio literature review to understand the impact of national political development objective on spatial planning, land use, water and environmental resource planning and management.”*

6.4 Water Sensitivity South Africa context specific

Part 1

Research Question: How can South Africa's existing legislative framework for water, the environment and land use give effect to the internationally and locally adopted concept of water sensitivity?

Part 2

Chapter 4 mainly sought to answer the above secondary research question. The first part (Part 1) of the research question was largely explored and addressed in Section 4.2.3.1, Section 4.2.3.2, Section 4.4.1 and Section 4.4.2 as it provides a synopsis of various strategic plans to be prepared by National, Provincial or Local government officials entrusted with powers and duties to give effect to a sustainable and productive environment - much of which has already been addressed in Chapter 3.

From the literature review, it became evident that South Africa has adopted an extensive suite of legislation that mandates various spheres of government to prepare and implement strategic planning documents to guide development within its respective sector. Section 4.2.3.1 provided a brief overview of South Africa key water legislation, the National Water Act No. 36 of 1998 and the Water Services Act No. 108 of 1997. Together they mandate the preparation and implementation of eight different, yet aligned, strategic planning documents to address both water resources quality and quantity. As for environmental resources planning, the study identified three key environmental legislations, including the National Environmental Management Act no 107 of 1998 (NEMA); National Protected Area Act no. 57 of 2003 and the National Biodiversity Act no. 10 of 2004. Together they mandate the preparation and implementation of eight strategic planning documents to protect and conserve the environmental resources. Last, but most importantly, Section 4.4 provided a review of the Spatial Planning and Land Use Management Act 16 of 2013.

SPLUMA mandates for the preparation and implementation of six strategic plans and one statutory planning document the Municipal land use scheme. In theory, if and when all of the above plans are prepared and implemented as initially intended (legislative content), strategic planning for land, water and environmental resources at local government will result in more realistic outcomes, rather than high-level assumptions. Adding additional water sensitive requirements to the proposed content of each plan will place water sensitive planning in an entirely new paradigm.

The empirical investigation, provided in Section 5.4.1.1 and Section 5.4.1.2, also consisted of an in-depth review of all nationally adopted legislation, policies and strategic plans engaged with either land, water and environmental resources planning and management. A synopsis of development directives and relevance to WSSP was provided in the Table 5-5 to Table 5-11.

As for the second part of the research question, “give effect to the internationally and locally adopted concept of water sensitivity” was explored in Section 4.4, which provided information in on the concept of water sensitivity as adopted by the WRC. Two key documents were reviewed in this section, including the South African Guidelines for Sustainable Drainage Systems (Armitage *et al.*, 2013) and the Water Sensitive Urban Design for South Africa: Framework and Guidelines (Armitage *et al.*, 2014). The later defined water sensitivity within South Africa’s context and identified three components to give effect to water sensitivity, one of which is urban planning. These two, documents have led the way (since 2013) for all research related to water sensitivity in South Africa. However, to date, limited information as to exactly how spatial planning and land use management should engage with the concept of water sensitivity. Based on Armitage *et al.*, (2014:viii) statement that “there is untapped potential for more extensive coordination which could be facilitated by the urban and strategic planning fora” – the researcher identified the municipal SDF and the municipal LUS as two planning tools to give effect to water sensitivity. Thus, Section 4.4.1 and Section 4.4.2 provided an in-depth discussion of each tool and identified several opportunities as to how SuDS and WSUD can be incorporated through spatial planning and land use management.

Based on the above synthesis, this study assisted in building a better understanding of the roles and responsibility of national, provincial and local government in terms of resources planning and management. It also identified opportunities for change by mean of the preparation and implementation of a water sensitive municipal SDF and a water sensitive LUS. This study therefore aimed to have addressed the following two research objective: *“Carry out a legislative and policy analysis to identify which strategic planning instruments can and must be used to*

inform WSSP, down to municipal level” and “Determine the extent to which exiting spatial planning and land use management tools give effect to WSSP”

6.5 Evidence Based planning

Research Question: How can spatial planning and land use management within the legislative framework of the Spatial Planning and Land Use Management Act (Act 16 of 2013) progressively intervene to secure future water resources availability on local municipal level?

Part 1

Part 2

Chapter 5 mainly sought to answer the above secondary research question. The first part (Part 1) of the research question was largely achieved through the empirical investigation’s methodology – founded on, various research methods, as discussed in Section 1.5, and taking a typical process through which, a Registered Town Planner will proceed in developing an SDF and/or LUS to give effect to SPLUMA. Section 5.4.2 explained the methodology in more detail. This approach was also used to develop a Framework for Water Sensitive Spatial Planning as provided in this study’s recommendations chapter.

The second part of the research question was addressed throughout the remainder of the empirical investigation. Securing future water resource availability is a two-fold process which requires a reduction in water demand as well as improved water quality. The latter which is also dependant on the natural functioning of its broader ecological environment.

In terms of reducing water demand, the empirical investigation focused on identifying the land use water quantify impact, identifying alternative sources of water resources and identifying suitable levels of access to services (based on affordability) for both Lephalale and Mogalakwena Local Municipality.

- Section 5.4.2.2.1 provided a new and innovative evidence based methodology for determining the land use water quantity impact. The findings of this analysis were that each land use has a water resources demand - quantified as the volume of consumed water. No direct link between the type of land use and the water demand was established,

making the analysis unique in each municipality. The analysis enables urban planners to identify spatial zones, in this instance, the zone was labelled Water Conservation and Demand Management Zone (WCDM Zone) where certain site-specific recommendations should be implemented - such as rainwater harvesting to substitute a percentage of municipal water demand by an alternative and water sensitive source. Building controls, as a function of a land use scheme, can also be used as an incentive where developers will be granted additional coverage if their site development plan makes provision for some form of water harvesting solution. See recommendations chapter for more detail on the implementation of the WCDM Zone. Also refer to key findings in Section 5.4.2.2.1.3.

- Following the Land Use Water Quantity Impact Model, Section 5.4.2.2.1 also provided a new and innovative evidence based methodology on how to calculate the Rainwater Harvesting Potential of an entire urban area. Although the findings were rather disappointing in term of potential volume to be harvested. The potential for Rainwater Harvesting will differ significantly if the analysis is conducted elsewhere in South Africa. Also refer to key findings in Section 5.4.2.2.1.3.
- Section 5.4.2.2.3 provided a new and innovative evidence based methodology on how to determine a water distribution network's UARL by density. The Density Water Loss Model is, however, dependent on detailed water distribution spatial data – which was not sufficient for Lephalale nor for Mogalakwena Local Municipality. Nevertheless, the Density Water Loss Model proved that higher density developments have a reduced volume of UARL. With this in mind, the implementing of densification strategies or growth management strategies through the SDF or LUS can result in securing future water resources as less water is lost through the distribution network. Also refer to key findings in Section 5.4.2.2.3.3.
- Throughout the study, an emphasis was placed on service delivery, the importance of eradicating backlog and achieving national and international targets to increase the number of households with access to water and sanitation services. Though well intended, the level of service to be provided to a certain community is often a political decision. While these communities might enjoy a higher level of access to services –unable to pay for such a high level of services has a major impact on the operation and maintenance regime of a distribution network. Water also becomes undervalued and misused in areas where non-payment for high levels of services may occur. For this reason, Section 5.4.2.3.1 set out to determine the percentage of households with access to services still considered to

be below basic RDP norms and standards, as well as, the percentage of households per subplace that has access to unaffordable levels of services. The case study revealed that in both municipalities – in some subplaces more than 80% of households within the income category, lower than R 19 000 per/annum, has access to piped water inside dwelling which is the highest level of services that a water services provider can provide.

- Section 5.4.2.3.2 provided a glimpse into the future land use water quantity demand – however, the study recommended that this analysis should become a detailed study of its own as multiple sophisticated growth models already exist. Linking water consumption by land use to one of these growth models (applicable to South Africa) can contribute significant evidence to this research theme.

Based on the above synthesis, this study aimed to have addressed the following research objective: *“Provide a new and innovative evidence based methodology on how to determine the land use water quantity impact.”*

In terms of increasing water quality, the empirical investigation focused on identifying the land use water qualitative impact, on a macro and micro-spatial scale for both Lephalale and Mogalakwena Local Municipality.

- As mentioned throughout this study, the quality of water resource depends on the state of its broader environment. For this reason, and Section 5.4.2.1.3 focused on quantifying the extent of land use impact on water quality on a macroscale. Various spatial areas were identified as environmental conflict areas where land use is posing either water quality or quantity implications. The evidence based analysis also identified areas posing environmental opportunity for Potential NPAES zones and FEPA Buffer zones. These zones should be implemented through the LUS whereas growth management strategies, a function of the SDF, can limit future growth direction where land use may be in conflict with areas of ecological significance. Also refer to key findings in Section 5.4.2.1.3.3.
- Section 5.4.2.1.2 provided a new and innovative evidence based methodology on how to determine the impact of land use on groundwater resources and prescribed certain land use management guidelines including borehole buffer zones, groundwater protection zones and high groundwater quality intervention zone. Also refer to key findings in Section 5.4.2.1.2.3.

- Section 5.4.2.2.2 provided a new and innovative evidence based methodology on how to determine the land use water quality impact for an urban area by linking a generic threats table to the land use data. Unlike the Land Use Water Quantity impact analysis, this analysis provided a clear correlation between a type of land use and the impact thereof on water quality. In both case studies, the spatial data revealed that industrial, public services infrastructure (roads) and utilities have the highest land use water quality impact. As such, recommendation for a land use water quality intervention zone was proposed. This zone should priorities the implementation of SuDS treatment train as per the South African Guidelines for Sustainable Drainage Systems (WRC Project No. K5/1826). See chapter on recommendations for further discussion. Also refer key findings in 5.4.2.2.3

Based on the above synthesis, this study aimed to have addressed the following research objective: *“Provide a new and innovative evidence based methodology on how to determine the land use water quality impact.”*

- The water sensitive compliance analysis provided in Section 5.3.2, illustrated that there is scope for SDF and LUS to become water sensitive as they currently do not address this theme of resource sustainability. For a water scares country, planning for water sustainability should become the main priority of all strategic and statutory plan. Also refer to key findings in Section 5.3.2.3.

Based on the above synthesis, this study aimed to have addressed the following research objective: *“Identify gaps and opportunities to address WSSP within exiting spatial planning and land use management documents.”*

Research Objective: Establish a framework for Water Sensitive Spatial Planning in South Africa.

- This study recommends that the proposed Framework for Water Sensitive Spatial Planning be adopted by all registered town planners and all local municipalities in preparation and implementation of SDF and LUS as mandated by the SPLUMA. Refer to Chapter 7 for detailed discussion.

Research Objective: Produce a guideline on how to develop and implement a Municipal Water Sensitive Spatial Development Frameworks (WSSDF) and a Municipal Water Sensitive Land Use Scheme (WSLUS) within the legal framework of SPLUMA.

- This study also recommends that the proposed Guideline for Compiling Water Sensitive Tools is used by all registered town planners and all local municipalities in preparation and implementation of SDF and LUS as mandated by the SPLUMA. Refer to Chapter 7 for detailed discussion.

CHAPTER 7 RECOMMENDATIONS

7.1 Introduction

Planning for land and planning for water resources existed side by side for many years. Yet, these two disciplines have failed to inform each other at a municipal scale. Based on the results provided by the empirical investigation and all other chapters leading up to the empirical investigation – this study proved that innovative and evidence based spatial planning and land use management tools can secure future water resources if decision-makers are made conscious about their land use water quantity and quality impact.

Thus, this study recommends a Framework for WSSP to be adopted by Local Government and all Professional Urban and Regional Planning Practitioners engaged with the responsibility of preparing and implementing spatial planning and land use management documents (tools). To inform technical aspects of the Framework, the study recommends that the Guideline for Compiling WSSP tools is used to inform the status quo analysis of an SDF and LUS in order to derive at water sensitive spatial proposals to guide future planning; and, water sensitive land use management zonings and scheme clauses to regulate existing land use and the impact thereof on water quantity and quality.

7.2 Framework for WSSP

One of the study's research objective was to "*Establish a framework for Water Sensitive Spatial Planning in South Africa.*" Informed by the literature review, the empirical investigation and the stakeholder engagements, the study puts forward A Framework of WSSP as illustrated in Figure 7-1. Adopted from the Department of Rural Development and Land Reforms procedural steps required in the process of preparing a municipal SDF (RDLR, 2014b:72) and LUS (RDLR, 2017:35). This Framework attempts to link the concept of water sensitive to the process of developing SDF and LUS by adding additional objectives, actions and outcomes that will ensure that water sensitivity throughout every phase.

Even though SPLUMA mandates each municipality to develop and adopt a SDF and LUS, very seldom will a municipality award both tender bids to the same services provider. For this reason, the Framework propose that a services provider appointed for either a SDF or LUS adopts Phase 1 and Phase 2 as standard practice. Thereafter, depending on the appointment, the service provider should choose between either Phase 3(A) (SDF) or Phase 3 (B) (LUS).

the process of requirements of developing a SDF is illustrated in Phase 3 (A) and the process of requirements of developing a LUS in Phase 3(B).

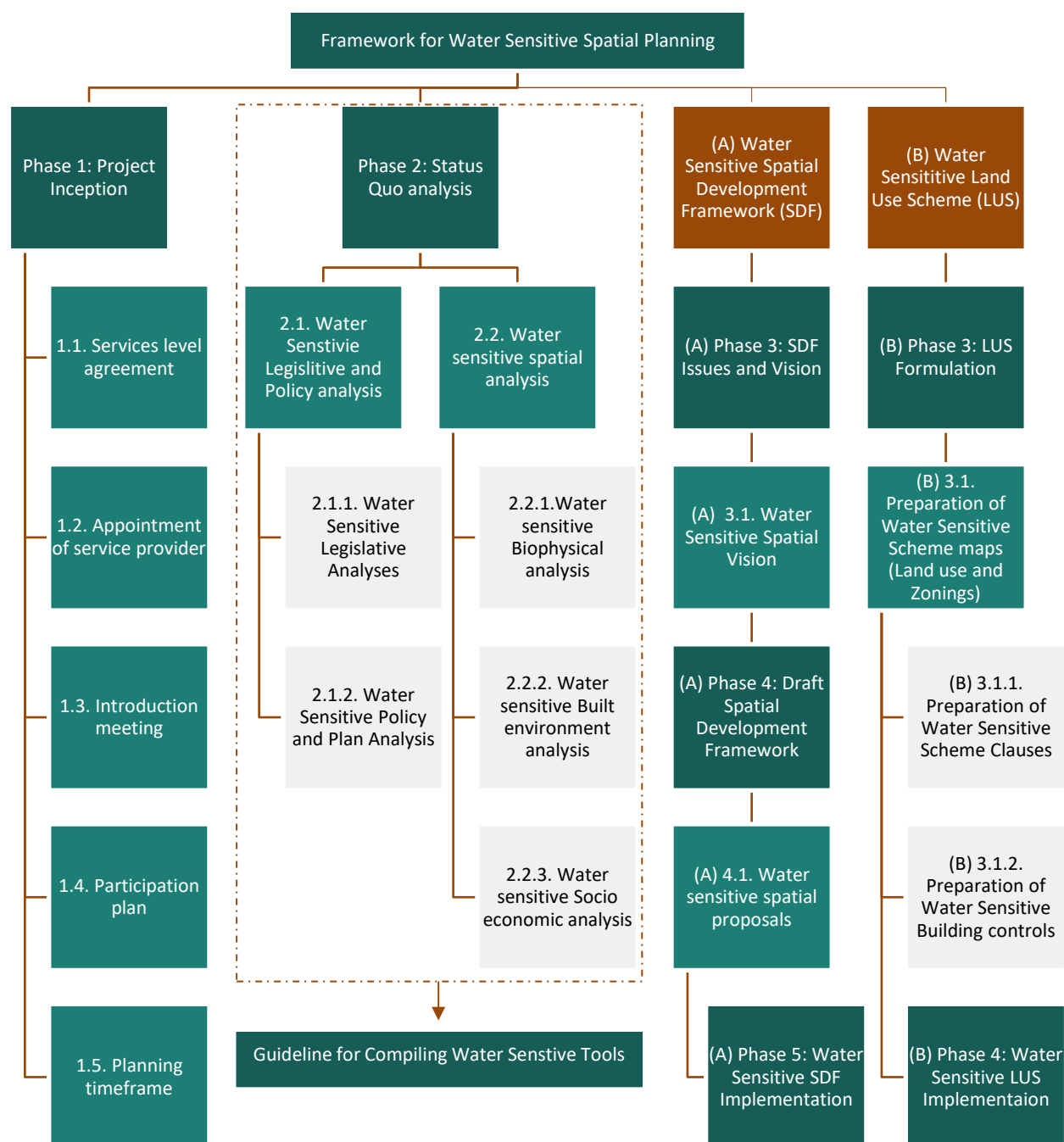


Figure 7-1: Framework for Water Sensitive Spatial Planning

Source: Own Construction (2019)

Table 7-1 provides a detailed discussion of each phase. Throughout, the Framework, more than 25 recommendations for WSSP is made.

Table 7-1: Framework for Water Sensitive Spatial Planning

Phase	Water Sensitive Objectives	Water Sensitive Outcome
Phase 1: Project Inception		
Phase 1.1. Services level agreement	The TOR for the development of municipal SDF and LUS are mostly standard and refers to Sections 20 and 21. Most municipalities appoint private sector Service Providers to compile the spatial planning documents required by law using an open tender process. Most often the professional team requirements for a service provider is only a registered Professional Town and Regional Planner. Water Sensitive Spatial Planning requires additional input e.g. • Geographic Information Systems Specialist - to assist in the modelling of spatial data as prescribed in the guideline document. • Civil engineer – Location, extent, condition and capacity of existing infrastructure networks. Quantification of additional infrastructure required to give effect to spatial proposals. • Environmental - Environmental sensitive inputs, location of water resources, inputs to planning (what should be conserved, where it is located etc.) • Landscape architect - Detail site specific considerations with regards to landscaping of green spaces in a water sensitive manner. • Stormwater engineer - Inputs into large scale natural stormwater features that may affect the future shape of the town or city. • Building Officer / Specialist - Evaluate and consult on building control clauses, specifically related to water sensitive urban design.	The Municipality will align its TOR for the preparation and implementation of SDFs and Land Use Schemes tender bids with this Framework for Water Sensitive Spatial Planning as well as the Guideline for Compiling Water Sensitive Tools. As a result, the Municipality will appoint a Services Provider with a project team consisting of a Registered Professional Town Planner, Geographic Information Systems Specialist, a Civil Engineer, an Environmentalist; Landscape Architect; Stormwater engineer; and a building officer with the necessary skills and competencies to ensure that the municipality's planning documents adheres to the Framework for Water Sensitive Spatial Planning as well as the Guideline for Compiling Water Sensitive Tools.
Phase 1.2. Appointment of service provider		
Phase 1.3. Introduction meeting	The introduction meeting is set to be the first engagement between the municipality's project coordinator and the Services Provider. This meeting also presents an opportunity for the appointed Service	The appointed Services Provider and Project Owner (the Municipality) adopts the objectives of Water Sensitive Spatial Planning and is capacitated with this

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	Provider together with the Municipal or the District Project Coordinator to discuss possible stakeholders be invited to the inception meeting. During phase 1.3, the Water Sensitive Spatial Planning Framework must be introduced to the Service Provider by the project coordinator to ensure that the framework is used during the process of compiling a SDF and/or a Land Use Scheme that addresses water sensitivity. This meeting should also be used as an opportunity for the project coordinator to share existing documents and data applicable to the project. In addition to the typical planning documents, the Services Provider must request to be provided with the following documents and spatial data (if any): • Municipal Water Services Development Plan (WSDP); • Infrastructure Master Plan and Infrastructure Asset Management Plan; • Provincial Water and Sanitation Master Plan; • Catchment Management Strategy (for their specific catchment); • Water Reconciliation Strategy (for their catchment); • All by-laws related to stormwater management and water and sanitation; and, • Flood line studies	Framework and Guideline for Water Sensitive Spatial Planning to influence to normal planning methodology. In addition, all water related document and data is provided to the Service Provider and all queries related to the information presented, is addressed by the custodians of such information.
Phase 1.4. Participation plan	Different forms of participation occur during the planning process. Firstly, to achieve water sensitive spatial planning the framework recommends that the steering committee includes a representative of the Water Services Providers and the Department of Water and Sanitation. Additional primary stakeholders' representatives to be included: • Municipal IDP officer • Municipal Department of Infrastructure Development • Catchment Management Agency: Representative	The steering committee acknowledge that managing land and water in a holistic manner is not possible without engaging those who are either using or who are responsible for taking care of the individual elements thereof via policy-making, legislation, regulation, construction, operations and maintenance. The participation plan therefore includes consultation with a strong interdisciplinary team who will need to: • provide input into the process of compiling a water sensitive Spatial Development Framework and/or a Water Sensitive Land Use Scheme;

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	- Environmental conservation and protection agency - National / Provincial representatives of Department of RDLR; Department of DWS; Department of Environmental Affairs; Housing and Human Settlements; Education and Health. Secondly, the plan should make provision for consultation with water sector professionals to ensure that other sectors are presented with the proposals as well as have time to provide input into the process. Additional secondary stakeholder representatives to be included: - Traditional Authorities / Community Members - Major water users (Eskom / Business, Farm, Industries) - Representative from Water Research Commission (WRC) / South Africa's National Biodiversity Institute / Biodiversity GIS (BGIS)/ Agricultural Research Council (ARC) - Provincial Growth and Development Agency	- share sector specific documents, policies and plans related to land, water and environmental resource planning and management; - ensure alignment with other water sector policies and plans; and, - approves the plan. Lastly, even though it is the responsibility of the Municipal Council to approve and adopt the LUS and SDF, it would be good practice to also have Water Services Authority (if not the Municipality) as well as the Department of Water and Sanitation to sign-off on the final plan.
Phase 2: Status Quo analysis		
Phase 2.1: Water Sensitive Legislative and Policy analysis		
Phase 2.1.1. Water Sensitive Legislative Analyses	The objective of phase 2.1. is to establish a baseline legal and institutional framework for the planning and management of land, water and environmental resources. In most spatial planning documents, a legislative analysis will be provided, yet the content will mostly be limited to a review of the Constitution, the Municipal Systems Act; SPLUMA; NEMA and the National Housing Act. In addition to the above, the Water Sensitive Legislative Analysis should aim to address the following key questions: Which National and Provincial Legislation, and Local Municipal Bylaws should inform the development of a Water Sensitive SDF and Water Sensitive Land Use Scheme?	The Service Provider is able to displays comprehensive knowledge on all legislation engaged with water, land and environmental resource planning and management and can display knowledge as to how the Legislation affect spatial planning and land use management on local municipal level. The status quo report will therefore include a summary all identified legislations and give effect to: - Vison and aims; - Key principles and development directives impacting on land / water / environment; and, - A summary of institutional mandates or arrangement and all strategic plans to be assessed in the next phase. The Water Sensitive Legislative Analysis will ensure alignment between the Municipality's spatial planning documents and relevant legislation. The Water

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	- Does the identified Legislations and Bylaws have a vision statement, aims or objectives that impose development directive for Water Sensitive Spatial Planning? - Can the findings of question (2) be addressed spatially or achieved through Water Sensitive Development Principles? - Which roles and responsibilities related to land, water and environmental resources planning and management has been assigned to National, Provincial, Local Government, and Sector Departments affecting the local municipality in question? Annexure A should be used to inform the Water Sensitive Legislative Analysis.	Sensitive SDF and Water Sensitive Land Use Scheme will therefore comply with SPLUMA.
Phase 2.1.2. Water Sensitive Policy and Plan Analysis	Aim of Phase 2.1.2. is to outline the development principles and strategies, goals and targets and other collaborative development initiatives and spatial informants or directives as contained in relevant National, Provincial and Local Municipal policies and plans impacting on land, water and environmental resource planning and management. The Water Sensitive Policy and Plan Analysis should aim to answer the following key questions: - Which national, provincial and local municipal policies and plans should inform the development of a municipal Water Sensitive SDF and/or Water Sensitive Land Use Scheme? - Does the identified policies and plans have a vision statement, aims, objectives or targets engaged with Water Sensitivity which the municipal Water Sensitive SDF and Water Sensitive Land Use Scheme must adhere to? - Can the findings of question (2) be addressed spatially or achieved through new development principles? Annexure B; Annexure C; and Annexure D are recommended to be used to inform the Water Sensitive Policy and Plan Analysis.	The Service Provider is able to display comprehensive knowledge related to the targets and key spatial development directives of all policies and plans as they engage with land, water and environmental resources planning and management. The Water Sensitive Policy Analysis, as contained in the Status Quo document strengthen inter-governmental alignment of development priorities. It also ensure that all plans and programmes are coordinated, consistent and in harmony with each other. The status quo report will therefore include a summary all relevant policies and plans - Vision and aims; - Key principles and development directives impacting on land / water / environment; - Targets to be achieved spatially impacting on land / water / environment.
Phase 2.2: Water Sensitive Spatial Analysis		

Phase	Water Sensitive Objectives	Water Sensitive Outcome
Phase 2.2.1. Water Sensitive Biophysical Analysis and Spatial Modelling	The objective of the Water Sensitive Biophysical Analysis is to limit the expansion of the built footprint onto areas of ecological importance (freshwater and groundwater resources) and to protect and expand ecological infrastructure and restore ecological functionality, specifically in freshwater ecosystem priority areas. A typical biophysical analysis usually includes maps and key finding related to the geology; slope; terrain types; soil classes; the climate of a region (limited to a map displaying the hydrological network e.g. Rivers and impoundments). In addition to the above, the Water Sensitive Biophysical Analysis should answer the following key questions: • What is the climate characteristic of the municipality? • Which physical structuring elements can be found within the municipality? • Which underlining geological characteristics has an impact on development and vice versa? • What is the extent of protected areas and areas of ecological significance? • Is groundwater resource development and managed aquifer recharge and option? • What is the quality of water resources in the study area? Annexure E as well as the Guideline to Compiling Water Sensitive Tools should be used to inform the Water Sensitive Biophysical Analysis and Spatial Modelling.	The Services Provider used the Guideline to Compiling Water Sensitive Tools to conduct a Water Sensitive Biophysical Analysis and Modelling Exercise where the climate, hydrological and geological characteristics of the municipality has been evaluated; areas of ecological significance has been identified; and the extent and land use environmental conflict and opportunity has been identified. This analysis should result in the following GIS layers to be used to inform the later stages of developing as Water Sensitive SDF and/or a Water Sensitive Land Use Scheme. Physical and underlining structuring elements • All physical structuring elements including undevelopable high slopes; primary and secondary rivers; Wetlands; estuaries and impoundments • All underlining structuring elements including dolomitic areas; impeded soil drainage areas; and areas with moderate to high and very high GWRP. Macro scale water quality and quantity assessment • All areas the good and bad surface and groundwater quality including areas with high sediment yield; very high sediment yield; Total Dissolvent Solids; Good GW quality; GW quality concern and high GW quality concern; • All areas with high and low availability of groundwater resource including Cumulative Neutralised Streamflow; very low UGEP and areas with very high UGEP. Protected areas and areas with management requirements • All ecologically stable areas including Untouched CBA ESA network; FEPA Buffer zone and Potential NPAES • all ecological conflict areas including modified PA; CBA and ESA; FEPA rivers; and Wetland Clusters.
Phase 2.2.2. Water Sensitive Built Environment Analysis and Spatial Modelling	The objective of the Water Sensitive Built Environment Analysis is to build an understanding of historic and current development trends and to determine the urban scale land use water quantity and quality impact. A typical built environment analysis usually includes maps and key finding related to land use, nodes and corridors. In addition to the above the Water Sensitive Built	The Services Provider used the Guideline to Compiling Water Sensitive Tools to conduct a Water Sensitive Built Environmental Analysis and spatial modelling exercise to determine the land use water quantity impact; rain water harvesting potential of the urban environment; land use water quality threats; and the potential for increased densities to reduce the volume of UARL in the water distribution network. This analysis should result in the following GIS layers

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	Environment Analysis should aim to answer the following key questions: • What is the municipalities land use water demand (in volume)? • Can high water demand by land use be narrowed down to specific geographic areas? • What is the rain water harvesting potential of the municipality's urban environment? • Can higher density development be accommodated within the exiting built-up footprint? • Is there potential to reduce UARL in the water distribution network? • What is the municipalities land use water quality impact? • Can high water quality impact by land use be narrowed down to specific geographic areas? • Can exiting natural and near-natural landscapes be utilised for the implementation of SuDS to treat highly polluted stormwater? Annexure E, Annexure G and the Guideline to Compiling Water Sensitive Tools should be uses to inform the Water Sensitive Biophysical Analysis and Spatial Modelling	to be used to inform the later stages of developing as Water Sensitive SDF and/or a Water Sensitive Land Use Scheme. Land use water quantity impact • Land use water consumption; • Areas where water conservation and demand management strategies should be priorities; and, • Quantify the Rainwater Harvesting Potential of a specific urban area. Land use water quality impact • Land use water quality impact related to: • sedimentation and turbidity • increased inputs of nutrients • increased toxic contaminants • concentration of salts (salinization) • pathogens (i.e. disease-causing organisms) • Areas where water quality intervention zone should be prioritised. Density of settlements • Areas to be prioritized for higher density development; and, • The potential to reduce the UARL of a distribution network within the existing development boundary.
Phase	Water Sensitive Objectives	Water Sensitive Outcome
Phase 2.2.3. Water Sensitive Socio-Economic Analysis and Spatial Modelling	The Socio-economic analysis strongly relates to the bio-physical and built environment ability to provide services to the municipalities residents and economic sectors. The objective of the Water Sensitive Socio-economic Analysis is therefore to determine the current and future socio-economic demand for water in order to identify opportunities for change. A typical socio-economic analysis makes use of statistical information to count and report on the number of households, population, and their access to basic services. Very seldom will access and backlog to basic services be identified spatially. Furthermore, the affordability of services is often	The Services Provider used the Guideline to Compiling Water Sensitive Tools to conduct a Water Sensitive Socio-Environmental Analysis and spatial modelling exercise to identify the current level of household access to services (Potable water and sanitation services); household backlog in services; the household affordability to levels of services; and, future household water demand. This analysis should result in the following GIS layers to be used to inform the later stages of developing as Water Sensitive SDF and/or a Water Sensitive Land Use Scheme. Services Assessment: Potable water • Household water source by subplace • Household access to piped water by subplace

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	ignored entirely. Therefor the Water Sensitive Socio-economic Analysis should answer the following questions: • Where does households receive their main source of water from and is the source reliable? • What is the current household level of access to services, and which settlements experience high levels of backlog in services (potable water and sanitation services)? • What is a sustainable level of access to services to be provided in areas experiencing high backlog? • Is the current level of services provided to households financially sustainable? (Household services affordability) • What is the future household demand for water services? Annexure G and the Guideline to Compiling Water Sensitive Tools should be uses to inform the Water Sensitive Socio-Economic Analysis and Spatial Modelling	• Household affordability to water services Services Assessment: Sanitation • Household access to sanitation services by subplace • Household affordability to sanitation services Future water demand • Future households water demand
Guideline to prepare a Water Sensitive Spatial Development Framework		
(A) Phase 3 of SDF: Issues and Vision		
(A) Phase 3.1. Water Sensitive Spatial Vision	The SPLUMA requires that the SDF prepare a spatial vision to inform the compilation of a SDF. Thus, the MSDF must include a written and spatial representation of a five-year spatial development plan to guide the future spatial form of the municipality (Section 21(b)) and include a longer-term spatial development vision statement which indicates a desired spatial growth and development pattern for the next 10 to 20 years (Section 21(c)). The key objective (with regards to water sensitivity) as far as establishing a spatial vision is to ensure that water sensitivity is in some way or form entrenched in the spatial vision of the SDF. Most often, it is not. At best, some aspects related to “sustainability” can be found in vision statements.	A spatial vision statement that incorporates water sensitivity to guide the development of the municipality’s Water Sensitive Spatial Development Framework. Armitage <i>et al.</i>, (2014:27) puts forward the following “narrative” that should be included in any Spatial Vision for any Municipality in South Africa: <i>“... mitigating water scarcity, improving water quality, thereby protecting ecosystems, through the development of water sensitive urban areas (for all) that are sustainable, resilient and adaptable to change, while simultaneously being a place where people want to live.”</i>
(A) Phase 4: Draft Spatial Development Framework		

Phase	Water Sensitive Objectives	Water Sensitive Outcome
(A) Phase 4.1. Water Sensitive Spatial Proposals	The objective of Water Sensitive Spatial Proposals is to: Mitigate water scarcity • ...<i>Growth Management Strategy</i> - by limiting the extent of development beyond settlement boundaries, reducing the need for extensive distribution pipelines, ultimately reducing the volume of UARL, and the demand for water resources; • ...<i>Densification Strategy</i> - by directing all future development towards more sustainable locations (existing node with potential to increase it carrying capacity/density) where infrastructure investment will focus on upgrades and maintenance rather than expansion of infrastructure; • ... <i>Spatial Targeting</i> - re-evaluating the level of services provided in certain areas and settlements based on availability of water resources and affordability of level of services. Though spatial targeting, Water Sensitive SDF should make recommendations for alternative services infrastructure (off-grid) in areas where services backlog is high and other areas where such solutions are feasible; • ... <i>Localised Spatial plans / precinct plans</i> - on a larger municipal scale, local water systems should be protected and rehabilitated to create blue-green corridor or integrated open space systems designed to create localised water catchments. These water resources could be utilised for local uses and re-used which reduces the demand for municipal treated water. • ... <i>Localised Spatial Plans / Precinct Plans</i> - implement spatial strategies to reduce water demand in certain zones. Improve water quality • ... <i>Growth Management / Densification strategy</i> - by limiting the extent of development beyond settlement boundaries, protecting the broader environment and its ecological	The Services Provider develop a Water Sensitive SDF, informed by the spatial outcomes of the Water Sensitive Bio-physical, Built and Socio-economic Analysis. The spatial proposals for the municipalities next 5, 10 and 20-years is therefore based on water sensitivity development objectives that will in future mitigate water scarcity and improve water quality. Spatial proposals for water sensitive settlements will therefore institute: • a Growth Management Strategy which is informed by a strict urban development boundary or urban edge; • Density Management that sets minimum densities within certain of the spatial structuring elements (nodes); • Detailed Localised Spatial plans / precinct plans promoting sustainable design and layout of future development, utilising existing blue green corridors for SuDS and other green infrastructure technologies. The SDF should determine the spatial allocation of land uses and mitigate the pollution potential by keeping land uses with a high pollution rating away from FEPA as well as groundwater resource areas. • Sustainable Future Levels of Services informed by household affordability to services, location of settlements, and feasibility of alternative solutions (Rainwater harvesting) to services. The municipality should only consider providing a higher level of service in a node in order to achieve specific aim (e.g. densification and compacting of a node). • Spatial Targeting of Nodes densification should be prioritised in certain nodes while levels of services should also be informed by the spatial targeting strategy

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	infrastructure necessary for the replenishment of polluted water resources; • ...<i>Growth Management strategy</i> - directing development away from areas of ecological importance including rivers, wetlands, high groundwater recharge zones etc. • ... <i>Spatial Targeting / Localised Spatial Plans / Precinct Plans</i> - by developing detailed spatial proposals for SuDS in areas where runoff is highly polluted by land uses. The layout and design of neighbourhoods must incorporate existing water systems and provide sufficient space for green infrastructure such as constructed wetlands and retention ponds which could be utilised for non-potable water uses and enhance water quality.	
(A) Phase 5: Water Sensitive Implementation		
(A) Phase 5.1: Water Sensitive Implementation and monitoring	SPLUMA requires A Municipal SDF to contain a Capital Investment Framework (section 21(n)) and a implementation plan (section 21(p) comprising of sectoral requirements, including budgets and resources for implementation; necessary amendments to a land use scheme; specification of institutional arrangements necessary for implementation; specification of implementation targets, including dates and monitoring indicators; and specification, where necessary, of any arrangements for partnerships in the implementation process. A Water Sensitive SDF should therefore identify Water Sensitive Projects, assign a budget and identify the responsible sector for implementation thereof. Furthermore, the Water Sensitive SDF must be reviewed at least every 5 years therefore a date of implementation should be assigned to each proposed project.	The Municipality adopts a Water Sensitive SDF informed by all of the above phases, and contains a implementation plan which identified sensitive projects for the next 5-year cycle which includes (e.g.): • Launch water audits in areas where irregular high-water demand is a concern and were billing data is lacking. • Implement a stormwater modelling study in areas identified to have high levels of land use water quality threat ratings. • Implement feasibility studies for the potential for alternative services in settlements experiencing high backlog in services • Development a Water Sensitive Urban Design Plan for areas with high economic investment potential • Implement a strategy to update the status of all PA, CBAs, ESAs, and FEPAs affected by development and priorities rehabilitation of such areas. The Water Sensitive SDF is approved by the Municipality as well as all primary and secondary stakeholders.

Phase	Water Sensitive Objectives	Water Sensitive Outcome
Guideline to prepare a Water Sensitive Land Use Scheme		
(B) Phase 3 LUS: Land Use Scheme Formulation		
(B) Phase 3.1. Preparation of Water Sensitive Scheme Clauses	Two aspects related to zonings apply to “water sensitive zonings”: • Zoning can allow OR restrict development • Zoning in older schemes were mostly restricted to urban areas. With new legislation, all land within municipal jurisdiction must be zoned. From a water sensitivity perspective, additional areas may require additional protection – more than what most land use schemes currently offer. These areas may not necessarily be “declared protected areas” but may be declared as agricultural zoning with no regard to water sensitivity. Water sensitive scheme clauses aims to: • Establish management overlay zones that identify areas requiring immediate intervention, as development to these areas may cause water quality and quantity related challenges; • Establish management overlay zones that identifies areas of future concern where development should be prohibited or limited; and • Established management overlay zones that will contribute to reduced water quantity demand and improved water quality outcomes.	Water sensitive scheme clauses including management overlay zones; building controls and/or development controls that legally enforced to development principles to ensure the protection of water resources and limit the water consumption footprint of existing and future developments. Examples of Water Sensitive Management Overlay Zones include: Environmental Management overlay zones: • Immediate Intervention Zone • Modified CBA's, ESA's, and FEPA's • Priority FEPA Rehabilitation Zone • Areas of future concern • Expansion of protected areas management overlay zone • Surface water protections and conservation management overlay zone • High Groundwater Quality Impact Zone or Groundwater Quality Improvement Zone • Groundwater protections and conservation management overlay zone • Borehole Protection Zone Settlement intervention overlay zones • WCWDM zone • Water Quality Intervention Zone • Blue-green corridor zone • High Density Development Zone Services interventions overlay zones • Household Services Intervention Zone • Off-grid development zone
(B) Phase 3.2. Preparation of Water Sensitive Building controls	At the time of writing no national standard for water efficiency in buildings could be found. The Land Use Scheme should therefore be used to bridge this gap until such a time as water efficiency is similarly dealt with. This would imply that a specific chapter (or clause) be added to the land use scheme, specifically to deal with water efficiency in buildings. Water sensitive building controls and/or Development controls should aim to:	Water sensitive scheme clauses including building controls and/or development controls that legally enforced to development principles to ensure the protection of water resources and limit the water consumption footprint of existing and future developments. Examples of Water Sensitive Management building and/or development controls include: Increased or reduced coverage • Increase allowable coverage from 70% to 82% if developers implement rainwater / stormwater harvesting or onsite water reuse technologies. The

Phase	Water Sensitive Objectives	Water Sensitive Outcome
	• Development Building and/or Development Controls to reduce the land use water quantity impact; and, • Development Building and/or Development Controls to reduce the land use water quality impact.	site development plan submitted with the application should include rainwater/ stormwater harvesting or water reuse techniques to store and re-use 30% of runoff. Increasing permeability • Introducing compulsory development controls or regulations to increase onsite permeability, either through permeable paving or natural vegetation which reduces the rate and volume of stormwater flow. Water Sensitive Building Controls • Water efficient domestic plumbing • Domestic and commercial irrigation • Private and public swimming pools • Rainwater / stormwater harvesting tanks • Onsite water re-use technologies
(B) Phase 4: Land Use Scheme Implementation		
(B) Phase 4.1: Land Use Scheme Consultation	The following should be considered as is good practise as far as it relates to the development of Water Sensitive Land Use Schemes: • Technical input is important. Throughout this document, emphasis has been placed on the fact that land uses consume water or can affect the quality of water. The practise of compiling a land use scheme, however, is normally left up to town planners, who are not water experts. It is therefore important that the land use scheme (earlier of possible) but at least in its draft version is circulated to water specialists for their input. • Participation vs. capacitation. It should be kept in mind that a land use scheme is a technical document. Yet, especially in traditional authority areas, the scheme expects the public to “do the right thing”. In addition, municipalities where traditional authorities are located, will have to rely on traditional authorities to apply the land use scheme in these areas (the municipalities simply do not have enough manpower to manage all land uses in every single village).	The Draft Water Sensitive Land Use Scheme was s circulated to water specialists and updated to incorporate their inputs. The Consultation phase of a land use scheme was used to TRAIN people in the principles of land use management and more specifically the land use impact on water resources quality and quantity. Examples of this type of consultation could include: • The actual demarcation of wetlands, mountain catchment areas, fresh water ecosystem priority areas etc. is not something that can be seen on the ground. This stage of the project can produce community maps with enough information to allow community leaders to identify landmarks in conjunction with the delineation of sensitive areas/or areas with specific management characteristics. These maps should then be used to ensure not allocation of land happens in these areas. • Training about the negative effects of certain land uses (e.g. overgrazing) could have on natural areas, riparian areas or wetlands. • The importance of buffer areas negating pollution around groundwater extraction points (e.g. boreholes).

Phase	Water Sensitive Objectives	Water Sensitive Outcome
		Many of the interventions should take on the form of basic land use management and water management rules of thumb that can assist traditional leaders in managing land and water effectively.
(B) Phase 4.2: Land Use Scheme Implementation	Once the consultation phase has been finalised and the council has adopted the land use scheme, it needs to be promulgated by placing a notice in the Government Gazette. This will inform all stakeholders and the public that the new scheme is now in operation. Another important component of the scheme includes the following: <i>Monitoring</i> <i>Updating the scheme</i>	<i>Monitoring.</i> Some of the interventions discussed in this Framework are proposed to influence consumer behaviour e.g. the recommendation compelling new houses in areas identified as Water Conservation and Demand Management Zones to implement rain water harvesting. Water consumption, therefore, should be monitored on a regular basis to make sure that the recommendation is indeed having the right effect. Also, new areas could manifest as using too much water, in which case the scheme can be amended to also consider new geographic areas. Similarly, the recommendations regarding land use management in traditional authority areas should also be closely monitored to ensure that traditional leaders are indeed implementing the scheme. In areas where is clearly not, additional capacity building and training may be required. <i>Updating the scheme.</i> The scheme can be updated whenever the municipality requires it, but AT LEAST every 5 years. This is a departure from previous thinking, which held that once in place, schemes are hardly ever updated. The scheme should be updated to reflect municipal as well as stakeholder policy, especially as far as water is concerned. Water scarcity is a relatively “new” concern in South Africa and in the next couple of years one can expect many innovations that could be enforced using the land use scheme

Source: Own Construction (2018)

7.3 Guideline to compile WSSP tools

The final objective of the study was to *“Produce a guideline on how to develop and implement a Municipal Water Sensitive Spatial Development Frameworks (WSSDF) and a Municipal Water Sensitive Land Use Scheme (WSLUS) within the legal framework of SPLUMA.”*

Following the Framework, this study recommends that Phase 2 of the framework (Status Quo Analysis) is conducted according to the guideline for Water Sensitive Legislative Analysis (Table 7-2) and the guideline for Water Sensitive Spatial Analysis (see Table 7-3):

Phase 2.1: Water Sensitive Legislative Analysis

- The Guideline for WSSP: Water Sensitive Legislative Analysis (see: Table 7-2) is based on a self-evaluation process of all National, Provincial, and Local Government legislation, policies and plans, engaged with land, water and environmental resources planning. Annexure A; Annexure B; and Annexure C, and Annexure D should be used to further inform the analysis.

Phase 2.2: Water Sensitive Spatial Analysis

- The Guideline for WSSP: Water Sensitive Spatial Analysis (see: Table 7-3) is a technical guideline consisting of various evidence based methodologies to determine the land use water quality and quantity impact. To avoid repetition, a series of cross-reference to Chapter 5 of this study was used. These detailed spatial modelling exercises requires for a person to have, at least, basic GIS skills. Table 7-3 is also informed by Annexure E which provides a list of spatial datasets, and Annexure G which provides the land use water quality threat rating as adopted from Macfarlane *et al.*, (2014).

Table 7-2: Guideline for WSSP: Water Sensitive Legislative Analysis

Phase 2 Status Quo Analysis		
Phase 2.1. Water Sensitive Legislative and Policy Analysis		Relevance to SDF / LUS
Phase 2.1.1. Water Sensitive Legislative Analysis	Identify and review National, Provincial legislation and Municipal Bylaws relevant to municipal spatial planning and land use management as well as water and environmental resources planning and management. 1. Asses the vision statement and key principles and determine whether it holds any spatial directives and how is it applicable to the municipality. 2. Identify and asses the roles and responsibilities mandated to various spheres of government or responsible authorities relating to land, water and environmental resource planning and management 3. Identify any regulations published in terms of the above identified legislations which sets out Norms and Standards which holds development implications or opportunities. 4. Identify any policies, strategies, frameworks and/or guidelines published in terms of the above identified legislations and list them for further discussion.	The SDFs mandate to give effect to and align with national, provincial and local government's legislation, policies and plans is captured in Section 13(3)(a)(b); Section 14(b); Section 15(3)(a)(b)(c); Section 16(a)(c)(f); Section 19(b) and Section 21(i)(m).
Phase 2.1.2. Water Sensitive Policy and Plan Analysis	Identify and review all National, Provincial, and Local Municipal policies relevant to municipal spatial planning and land use management as well as water and environmental resources planning and management. 1. Asses the vision statement and key development principles and determine whether it holds any spatial directives and how is it applicable to the municipality. 2. Asses the aims, objective and targets (if any) relating to land, water and environmental resource planning and management. Identify and review all National, Provincial, and Local Municipal strategic sector plans relevant to municipal spatial planning and land use management as well as water and environmental resources planning and management 1. Asses the vision, mission, objective and desired outcome of the plans. 2. Identify and review development principles and highlight any spatial directives. 3. Identify all projects which might have a physical, environmental and socio-economic impact on the municipality. This may include the physical development of new infrastructure, the expansion of protected areas, and other mega project deemed to create socio-economic growth in investment opportunity. 4. Identify all budgets allocated to the implementation of the plan and identify the potential beneficiaries (communities) 5. Identify existing development constraints (Overutilization of resources; resource pollution; infrastructure integrity) and future development opportunities (groundwater potential)	While a municipal LUS has the force of law, it must give effect to and align with national, provincial and local government legislation, policies and plans as set out in section 24 (2)(b); 27(1) and 29(1) of the SPLUMA. The Water Sensitive Legislative Analysis and Water Sensitive Policy Analysis takes into account National visions, Strategies and development directive engaged with land, water and environmental resources planning and management. The findings of Phase 2.1.1 and Phase 2.1.2. must translate into water sensitive spatial proposal and land use management guidelines.

Table 7-3: Guideline for WSSP: Water Sensitive Spatial Analysis

Phase 2.2: Water Sensitive Spatial Analysis		
Phase 2.2.1. Water Sensitive Biophysical analysis		
Phase 2.2.1.1 Physical and underlining structuring elements	Table 5-13: Physical and underlining structuring elements methodology	
	Relevance to SDF	Relevance to Land Use Scheme
	The findings of the physical and underlining structuring elements should inform: • Growth management strategy - o The municipality should implement a growth management strategy for direct development away from physical structuring elements such as undevelopable high slopes, rivers and river buffers, wetlands and impoundments (see Phase 2.2.1.4 Environmental protection and management requirements for more detail) • Rehabilitation strategy - o Wetlands and river buffer zones located at the bottom of steep slopes should be prioritised for revegetation – in terms of SuDS selection, filtered strips are commonly used along stream banks as vegetated buffer systems and also downstream from agricultural land to intercept and infiltrate stormwater runoff. • Households reallocation strategy - o Households located in flood lines should be prioritised for reallocation of stands, especially those located at the bottom of steep slopes close to rivers as they are most at risk of flooding. • Feasibility study for constructed wetlands - o Areas with impeded soil drainage are known to support wetlands. As such, areas with impeded soil drainage can lend itself towards the development of constructed wetlands to treat stormwater runoff or effluent from nearby settlements. • Feasibility study for Managed Aquifer Recharge	The findings of the physical and underlining structuring elements analysis should inform the development of: • Management overlay Zone – Potential Groundwater Development Zone - o Should be assigned to land parcels with high groundwater recharge potential. The management overlay zone should regulate the intensity as well as the permeability of land uses within the zone. Focus should be placed on SuDS treatment and revegetation of impermeable surfaces. - Step 1 Consult a groundwater specialist to confirm the groundwater development potential. Once the potential is confirmed - community members and property owners must be consulted on their land use impact on the underlining resource. - Step 2 The land use scheme MUST implement a Development Controls to increase Permeability in “Potential Groundwater Development Zone” – increased permeability can be achieved through permeable paving or soakaways. - Step 3 Specialized investigation on Managed Aquifer Recharge potential should be prioritised in the zone. • Take cognisance of Impeded Soil Drainage and High Swelling Clay Potential - o The Municipal land use scheme should take cognisance of areas with underlining structuring elements such as Impeded Soil Drainage and High Swelling Clay Potential as it can cause damage to buildings in storm events. Land use activities taking place on areas with impeded soil drainage characteristics can also have a negative qualitative and quantitative impact on

	o Launch feasibility study for Managed Aquifer Recharge through artificial borehole injection in areas with Moderate to high and very high GWRP.	surface and groundwater resources in as they commonly support wetlands.
Phase 2.2.1.2 Macro scale water quality and quantity assessment	Table 5-14: Macroscale water quality and quantity assessment methodology	
	Relevance to SDF	Relevance to Land Use Scheme
	The findings of the macro scale water quality and quantity assessment should inform: • Growth management strategy - o The municipality should implement a growth management strategy for direct development away from physical structuring elements such as undevelopable high slopes, rivers and river buffers, wetlands and impoundments (see Phase 2.2.1.4 Environmental protection and management requirements for more detail) - o The municipality should implement a growth management strategy that directs development away from Surface water quality intervention zone; High Groundwater Quality Impact Zone or Groundwater Quality Improvement Zone; and Groundwater protections and conservation management overlay zone to improve both water quality and quantity. • Rehabilitation strategy - o Wetlands and river buffer zones affected by development should be prioritised for	The findings of the macro scale water quality and quantity assessment should inform the development of: • Management Overlay Zone: Surface water quality intervention zone - o Areas identified as surface water quality concern areas should be prioritised for land use interventions including the revegetation and implementation of SUDS in sensitive areas, especially in river and wetlands buffer zone areas. Filtered strips alongside rivers and wetland buffers can reduce the amount of sediment deposits. Develop in this overlay should be limited restricted or informed by a detailed EIA. • Management Overlay Zone: High Groundwater Quality Impact Zone or Groundwater Quality Improvement Zone - o Should be assigned to areas identified to have groundwater quality concern - which includes land parcels with high groundwater recharge potential, modified by artificial land uses to some extent and has a high impact on water quality. This overlay zone is a reactive measure towards water sensitive spatial planning and land use management. Step 1 Consult a groundwater specialist to confirm the quality as well as the root cause of pollution of the underlining water resources. Step 2 Once the quality is confirmed, and the root cause identified - community members and property owners must be consulted on their land use impact on the underlining resource. Step 3 The management overlay zone should regulate the intensity as well as the permeability of land uses within the zone. Focus should be placed on stormwater treatment and revegetating impermeable surfaces. The groundwater quality impact must be lowered in order to protect the resource. All future developments within the "Groundwater quality improvement zone" MUST accommodate SUDS and WSUD to prevent further pollution. Step 4 Specialized investigation on Managed Aquifer Recharge potential should be priorities in the zone. Step 5 This management overlay zone should be amended (5-year iteration) or removed when land under discussion is no longer of concern.

	revegetation and removal of alien invasive species. - Biodiversity stewardship programs - Communities located close to Surface water quality intervention zone; High Groundwater Quality Impact Zone or Groundwater Quality Improvement Zone; and Groundwater protections and conservation management overlay zone should be identified as potential beneficiaries of Biodiversity Stewardship Programs.	- Management overlay Zone: Groundwater protections and conservation management overlay zone - Should be assigned to areas of land with high groundwater recharge potential in natural state. This overlay zone is a pro-active measure towards water sensitive spatial planning and land use management. - Step 1 Consult a groundwater specialist to confirm the groundwater recharge potential of the areas. - Step 2 Once the quality is confirmed, delimited areas of high importance. Specialized investigation on Managed Aquifer Recharge potential should be priorities in the zone. - Step 3 Assign the “Groundwater protections and conservation management overlay zone” to the areas of high importance and notify potential affected parties about the protective status of the area. The zone should remain in natural state for as long as possible. - Step 4 This management overlay zone can be amended (5-year iteration) but should not be removed for as long as possible.
Phase 2.2.1.3 Environmental protection and management requirements	Table 5-15: Environmental protection and management requirements methodology	
	Relevance to SDF	Relevance to Land Use Scheme
	The findings of the environmental protection and management requirements assessment should inform: - Growth management strategy - The municipality should implement a growth management strategy that directs development away from Areas of future concern; Priority FEPA Rehabilitation Zone to protect and improve both water quality and quantity. - Master planning for ecological infrastructure	The findings of the environmental protection and management requirements assessment should inform the development of: - Management overlay Zone: Immediate Intervention Zone - Should be assigned to areas which are supposed to be protected by law, however due to unregulated and illegal land use activities, the protected areas status is under threat. The overlay zone is a reactive measure towards water sensitive spatial planning and land use management. - Step 1 Inform the authority responsible for the management and conservation of the protected area that illegal land use activities are being exercised within the Protected Area. - Step 2 Verify the spatial data by means of a site inspection. - Step 3 Confirm the extent and cause of the illegal land invasion and identify stakeholders willing to interact for communication purposes. - Step 4 Develop a protected areas intervention and rehabilitation plan – This plan should address the rehabilitation of land process and address the re-location of settlements or other land use. - Step 5 This management overlay zone should be amended (5-year iteration) or removed once the land under discussion is rehabilitated to its natural state. - Management overlay Zone: Modified CBA's, ESA's, and FEPA's

	o The municipal SDF should include a Ecological infrastructure master plan the at connects ecological corridors and open spaces.	- o Should be assigned to areas Modified CBA's, ESA's, and FEPA's would not necessarily receive an overlay zone, as the spatial data indicates that the ecological significances of the CBA's and ESA's under discussion has already been destroyed by development. However, the aim is to confirm whether the management status still applicable to the CBA and ESA in question. This is both a reactive and preventative measure towards water sensitive spatial planning and land use management. - Step 1 Verify the spatial data by means of a site inspection. - Step 2 Engage with the environmental specialist responsible for generating the original spatial datasets and confirm the status of CBAs, ESAs and FEPAs in question. - Step 3 If these CBAs, ESAs and FEPAs have been modified to a point of no rehabilitation – it is recommended that the management status should be removed for the land parcels. - Step 4 Removing the management status from CBAs, ESAs and FEPAs will provided a more realistic understanding of the full extent of remaining CBAs, ESAs and FEPAs. This will also facilitate the prioritization of capital spending, protection and conservation of other CBAs, ESAs and FEPAs in good ecological condition. • Management overlay Zone: Priority FEPA Rehabilitation Zone - o is a management overlay zone or buffer zone assigned to land parcels with a FEPA management status, affected by other land uses but which can still be rehabilitated to its natural state. This overlay zone is a reactive measure towards water sensitive spatial planning and land use management. - Step 1 Verify the spatial data by means of a site inspection. - Step 2 Engage with stakeholder/s (community members) associated with the land use activities affecting FEPA and their buffer zones and communicate and discuss the threats and concerns posed by such activity. - Step 3 In consultation with the affected parties and environmental specialist develop a rehabilitation strategy for FEPA. Other affiliations such as Working for Water; Working for Wetlands and adopt-a-river program should be consulted as well. - Step 4 This management overlay zone should be amended (5-year iteration) or removed if FEPAs under discussion is rehabilitated and no longer of concern. A new management overlay zone should then be assigned for the FEPAs – (see the section below). • Management overlay Zone: Areas of future concern - o Areas of future concern is a management overlay zone or buffer zone assigned to land parcels close to exiting protected areas; CBAs, ESAs and FEPAs experiencing high development pressure from other land uses. This overlay zone should be used as a preventative or pro-active forward planning approach towards water sensitive spatial planning and land use management.

		Step 1 Inform the authority responsible for the management and conservation of the Protected Areas as well as the stakeholder/s (community members) associated with the land use activities encroaching protected areas. Step 2 Verify the spatial data by means of a site inspection. Step 3 Engage with the stakeholder/s or community members and communicate and discuss the threats posed to Protected Area, CBAs, ESAs and FEPAs by the settlement's natural growth direction. Step 4 In consultation with the affected parties, develop a growth management strategy which assigns a new growth direction (away from protected areas) and a strict development boundary to the settlement area and land use in question. Densification of existing settlement footprint should be promoted, if possible. Step 5 If CBAs, ESAs and FEPAs are located within the new development boundary, a land use zoning such as "Public Open Space" can be assigned to the land is questioning to protect the area form other land uses. Step 6 This management overlay zone should be amended (5-year iteration) or removed if land under discussion is no longer under threats • Management overlay Zone: Expansion of Protected Areas Network - o is a management overlay zone assigned to CBA's and ESA's in good ecological condition and within proximity (2km) to existing Protected Areas. Step 1 This area of land is identified to form part of the NPAES zone requires further assessment as per the 2008 National Protected Areas Expansion Strategy. Assessment is based on "Importance" and "Urgency." Step 2 Assessment should be conducted by the authority responsible for protected areas. Step 3 Once the land in question have been confirmed, the "NPAES zone" should remain in place until these areas have been legally declared as protected areas. Step 4 The management zone can also be amended to accommodate "Biodiversity stewardship agreements." Step 5 All remaining CBA's and ESA's must be managed as prescribed by the bioregional plan's guidelines for land use management of CBA's and ESA's

Phase 2.2.2. Water Sensitive Built Environment Analysis

Table 5-16: Land use water quantity assessment methodology

	Relevance to SDF	Relevance to Land Use Scheme
Phase 2.2.2.1 Land Use Water Quality Impact	The findings of the land use water quantity assessment should inform - Localised Spatial plans / precinct plans - Areas identified in the assessment as Water Conservation and Demand Management Zones (WCDMZ) should be prioritised for the implementation of water demand management strategies. Such areas can become subject to trickle flow regimes or be charged with higher water tariffs. Largescale rainwater and stormwater harvesting ponds can be included in the design of these zones where water resource can be harvested and used to non-potable water requirements. - The rainwater harvesting analysis should inform the localised spatial plan and the WCDM strategy.	The findings of the land use water quantity assessment should inform the development of: - Management Overlay Zone: WCWDM zone - Should be assigned to areas or parcels of land with irregular high-water usage. This overlay zone is a reactive measure towards water sensitive spatial planning and land use management. The overlay zone and development control can also be assigned to new development areas – therefore making the water sensitive before actual development takes place. - Step 1 Conduct a water audit for all buildings in the zone - Step 2 Clauses relating to building controls and Development Controls (See below) - Water Sensitive Building Controls - Water efficient domestic plumbing - Typical commercial flush toilets should be retrofitted with ultra-low-flow or high efficiency single flush or dual-flush toilets. Urinals can be replaced with dry or urine diversion urinals. Typical faucets and shower heads can be retrofitted with low-flow or aerator heads. These possible strategies are easy and cost effective and can save between 20% and 50% of water. Water intensive appliances such as washing machines should in time be replaced with water efficient appliances. - Domestic and commercial irrigation - There are two areas to focus on system improvements which includes control upgrades and distribution system enhancements. Control upgrades includes the utilization of weather-based smart controllers, implementation of master flow control meters, implementation of soil moisture sensors and/or rain gauges for localized data point. Distribution systems enhancements includes the retrofitting of sprayers with high efficiency nozzles, ensure properly sized rotors and spray heads, utilized sub-surface drip irrigation where economically feasible and high efficiency pumps. Drip irrigation systems involve installing thin pipes directly to the base of plant, with drippers on the end of the pipes. These drippers slowly supply water to the plant directly where it is needed, so less water is required. The amount of water used for irrigation can be reduced by 50% or more using such a system. Reducing a lawn sizes and encouraging water wise garden can have a significant impact on water uses. Consider limiting the size of lawns when a site development plan is submitted. - Private and public swimming pools - Swimming pool water use is influenced by a variety of factors including the size of the pool, evaporation rates of climate, frequency of backwashing, leaks and splash-outs, water temperature as well as the pH and chemical content of the pool. The use of insulation, such as

		a solid pool cover can eliminate almost all evaporation. Consider limiting the size of swimming pools when a site development plan is submitted. - o Water harvesting tank - A decentralized rainwater harvesting system can be installed to almost all roofs and other elevated impervious surfaces such as covered parking bays. Rainwater harvesting is most effective on a corrugated iron, pitched roof typically associated with modern buildings. Rainwater harvesting utilizes stormwater for non-potable uses such as gardening and toilet flushing and thus contributes to water conservation. Stormwater storage facilities can also be connected to other SuDS options such as infiltration trenches or soakaways which increase the recharge volume. This approach can become a centralised water harvesting systems which can redistribute the harvested water to communities for irrigation or other non-potable uses. Rainwater harvesting can also become the main source of water supply where centralised alternatives are not available. However, rainwater harvesting is constrained by local rainfall characteristic and on-site and off-site space availability, and the storage tank size. • Water Sensitive Development Controls - o Coverage - The coverage element of building controls determines the percentage of a property that can be developed (e.g. 60% for residential buildings). Building footprint relates to runoff in the sense that the larger the footprint, the larger the runoff volume generated. Water sensitivity calls for using rainwater instead of allowing this to dissipate as runoff. The Coverage building control can be leveraged in new buildings to achieve this. The developer of a new building can be incentivized by making a portion of the property coverage CONDITIONAL to rainwater catchment and harvesting. The table below illustrates this principle in the case of Residential 3 (group housing, retirement villages etc.) zoned properties Coverage - The coverage element of building controls determines the percentage of a property that can be developed (e.g. 60% for residential buildings). Building footprint relates to runoff in the sense that the larger the footprint, the larger the runoff volume generated. Water sensitivity calls for using rainwater instead of allowing this to dissipate as runoff. The Coverage building control can be leveraged in new buildings to achieve this. The developer of a new building can be incentivized by making a portion of the property coverage CONDITIONAL to rainwater catchment and harvesting. The table below illustrates this principle in the case of Residential 3 (group housing, retirement villages etc.) zoned properties. <table border="1"> <thead> <tr> <th rowspan="2">Existing Development Control</th><th colspan="2">Proposed Development Control</th></tr> <tr> <th>Allowable coverage with no rainwater harvesting</th><th>Allowable coverage with rainwater harvesting</th></tr> </thead> <tbody> <tr> <td>80% of the extent of the property may be developed.</td><td>70%</td><td>82% The site development plan submitted with the application should include rainwater harvesting techniques to store and re-use 30% of runoff.</td></tr> </tbody> </table>	Existing Development Control	Proposed Development Control		Allowable coverage with no rainwater harvesting	Allowable coverage with rainwater harvesting	80% of the extent of the property may be developed.	70%	82% The site development plan submitted with the application should include rainwater harvesting techniques to store and re-use 30% of runoff.
Existing Development Control	Proposed Development Control									
	Allowable coverage with no rainwater harvesting	Allowable coverage with rainwater harvesting								
80% of the extent of the property may be developed.	70%	82% The site development plan submitted with the application should include rainwater harvesting techniques to store and re-use 30% of runoff.								

		In the above example, the developer has an allowable coverage with no rainwater harvesting at 70%. If the development implements rainwater harvesting / stormwater harvesting or water reuse technologies the allowable coverage will increase to 82%.
Phase 2.2.2.2 Land use water quality analysis	Table 5-16: Land use water quantity assessment methodology	
	Relevance to SDF	Relevance to Land Use Scheme
	The findings of the Land use water quality assessment should inform • Spatial Targeting through localised Spatial plans / precinct plans - o to be assigned to areas identified as high-water quality threat zones. These zones will require in-depth stormwater analysis to inform the detailed Water Sensitive Urban Design plan. The plans should make use of SuDS to reduce the land use water quality impact. See Section 5.4.2.2.2 for further detail. • Growth management strategy - o The municipality should implement a growth management strategy which limits the expansion of impervious surfaces beyond the existing built footprint. In this regard, surrounding natural environment will be protected and maintain ecological function. One such function includes the	The findings of the land use water quantity assessment should inform the development of: • Management Overlay Zone: High Water Quality Impact Zone - o Should be assigned to areas or parcels of land with high pollution ratings – causing high levels of polluted runoff. The aim of this zoning is to increase the permeability of an area or land parcel to reduce the runoff volume, and to treat polluted stormwater before it enters the natural hydrological system. This overlay zone is a reactive measure towards water sensitive spatial planning and land use management. Step 1 Conduct a stormwater impact analysis of specific areas or land uses with a high pollution rating. Step 2 Determine the existing coverage control measures and develop new coverage control measure for new developments. Step 3 Conduct a stormwater modelling exercise to determine in which directions polluted stormwater will travel. Step 4 Use SuDS guidelines document to implement a treatment train connected to the blue-green development corridor. (See Section 5.4.2.2.2 for more detail) Step 5 This management overlay zone should be amended (5-year iteration) to accommodate new features and greater areas of intervention. Step 6 Clauses relating to building controls and Development Controls (See below) • Permeability – permeability of a site is often ignored in a scheme, yet any sites impermeable surface should be considered as part of coverage as it has the same impact on stormwater runoff. - o The scheme clauses should introduce compulsory development controls or regulations to increase onsite permeability, either through permeable paving or natural vegetation can contribute to water sensitivity in the following manner: - o Stormwater runoff is returned to groundwater resources opposed to increased runoff flowing over streets and other impervious surfaces becoming contaminated and returned to the natural environment in a polluted state. - o Rain water may be harvested straight away if the paving and substructure is so designed that the absorbed water is collected underground. From here it may be pumped for use in the surrounding landscape or otherwise.

	purification of runoff. For this reason, a growth management strategy can contribute to improving water quality.	- o It is proposed that a permeability development control should be introduced applicable to all zonings where a percentage of all paving on a property should be permeable. • Management Overlay Zone: High Water Quality Impact Zone - o Blue-green corridor zone is a management overlay zone assigned to land identified to form part of a connected system of ecological infrastructure. This overlay zone is both a preventative and pro-active measure towards water sensitive spatial planning and land use management. Step 1 Verify the spatial data by means of a site inspection. Step 2 Engage with stakeholder/s (community members & property owners) associated with the land in question. Step 3 Confirm whether the land identified during the analysis is available to for part of the blue-green corridor as design the corridor overlay zone accordingly. Step 4 The overlay zone should be accommodated by a blue-green corridor development and management plan. Ideally, the plan should delineate internal zones to accommodate SuDS implementation. Step 5 This management overlay zone should be amended (5-year iteration) to accommodate new features.
Phase 2.2.2.3. Settlement form: Densification	Table 5-31: Settlement form: Densification and Density Water Loss Model	
	Relevance to SDF	Relevance to Land Use Scheme
	The findings of the Land use water quality assessment should inform • Densification strategy - o The municipality should implement a densification strategy which like the growth management strategy, limits the expansion of the built footprint. - o The spatial development framework should specify minimum densities within certain of the spatial structuring elements (e.g. Nodes). Main nodes or mixed-use nodes	The findings of the Settlement form Density assessment should inform the development of: • Management Overlay Zone: Higher Density Development Zone - o High Density Development Zone is a management overlay zone assigned to areas or parcels of land within the existing built up area, mostly targeted at vacant land, to promote and accommodate higher density developments. This overlay zone is a pro-active measure towards water sensitive spatial planning and land use management. By increasing development density, natural landscapes on the outskirts of the development boundary is protected from development. Water infrastructure networks in higher density development zones have a lower physical water loss rating. The overlay zone and development control can also be assigned to new development areas – therefore making the water sensitive before actual development takes place.

	should in general have a higher density than other areas of the municipality. This should also not only be limited to urban areas. Traditional villages for example can also be made more compact through the allocation of smaller stands. o Higher density development can accommodate more people within a small geographic area. Higher capital investment is often associated with higher density development therefore alternative SuDS strategies can also be funded in these areas.	Step 6 Higher density development zone can be assigned to any area within the existing development boundary. Step 7 This management overlay zone should be amended (5-year iteration) to accommodate new areas appropriate for higher density development. o Higher densities or a compact settlement pattern is land-intensive, with medium-high densities, mixed-use land policies forming a continuous footprint where growth is adjacent to consolidated areas. Densely populated settlements induce a more cost-effective use of infrastructure as the cost of installation and maintenance per sq. meter is lower since there are more taxpayers in the area to pay for them. This could ultimately present an opportunity for municipalities to introduce development incentive for private developers when taking the “green” approach to developments. Mixed use development e.g. business and residential units as one building could introduce water savings infrastructure such as water harvesting or greywater re-use systems.

Phase 2.2.3. Water Sensitive Socio-economic Analysis

Table 5-33: Levels of services - Water supply and sanitation methodology		
2.2.3.1. Services assessment: Potable water and sanitation services	Relevance to SDF	Relevance to Land Use Scheme
	The findings of the Services assessment should inform • Spatial Targeting through localised Spatial plans / precinct plans - o to be assigned to areas identified as high-water quality threat zones. These zones will require in-depth stormwater analysis to inform the detailed Water Sensitive Urban Design plan. The plans should make use of SuDS to reduce the land use water quality impact. See Section 5.4.2.2.2 for further detail. - o by developing detailed spatial proposals for SuDS in areas	The findings of the Settlement form Services assessment should inform the development of: • Management Overlay Zone: Household Services Intervention Zone - o Household Services Intervention Zone is a management overlay zone assigned to settlements where high levels of services are provided to households which cannot afford the level of services. This overlay zone is a reactive measure towards water sensitive spatial planning and land use management. The overlay zone and development control can also be assigned to new development areas – therefore making the water sensitive before actual development takes place. - o The overlay zone and development control can also be assigned to new development areas – therefore making the water sensitive before actual development takes place. - Step 1 Conduct a water audit of all water uses in the zone - Step 2 Identify areas where water-reuse can take place - Step 3 Implement a targeted water conservation and demand management strategy. • Management Overlay Zone: Off-grid development zone - o should apply to settlements with high levels of existing backlog to services and where households cannot afford to pay for services. This overlay zone is a reactive measure towards water sensitive

	where runoff is highly polluted by land uses. The layout and design of neighbourhoods must incorporate existing water systems and provide sufficient space for green infrastructure such as constructed wetlands and retention ponds which could be utilised for non-potable water uses and enhance water quality.	spatial planning and land use management. The overlay zone and development control can also be assigned to new development areas – therefore making the water sensitive before actual development takes place Step 1 Conduct a services audit and determine the full extent of existing backlog. Step 2 Identify alternative sources such as rainwater harvesting, stormwater harvesting, groundwater utilization and where possible – water reuse. Step 3 Identify alternative technologies suitable for sanitation services. Dry sanitation technologies should be prioritized in these settlements. Step 4 Workshop the services plan with municipal authorities and community member and aim for community buy in.

Source: Own Construction (2018)

7.4 Conclusion

Future water resources can be secured through innovative spatial planning tools, if land use water quality and land use water quantity impact are addressed throughout municipal SDF and LUS in a water sensitive manner. While research and development of concepts and theories related to water sensitivity was mostly, limited to site scale engineering solutions such as SuDS and WSUD, South Africa now has the opportunity to give effect to the second component of water sensitivity – through the Framework and Guideline for WSSP (also referred to as WSUP by Armitage *et al.*, (2014). Figure 7-2 contextualise this study and its contributions within the WRC framework for water sensitive design.

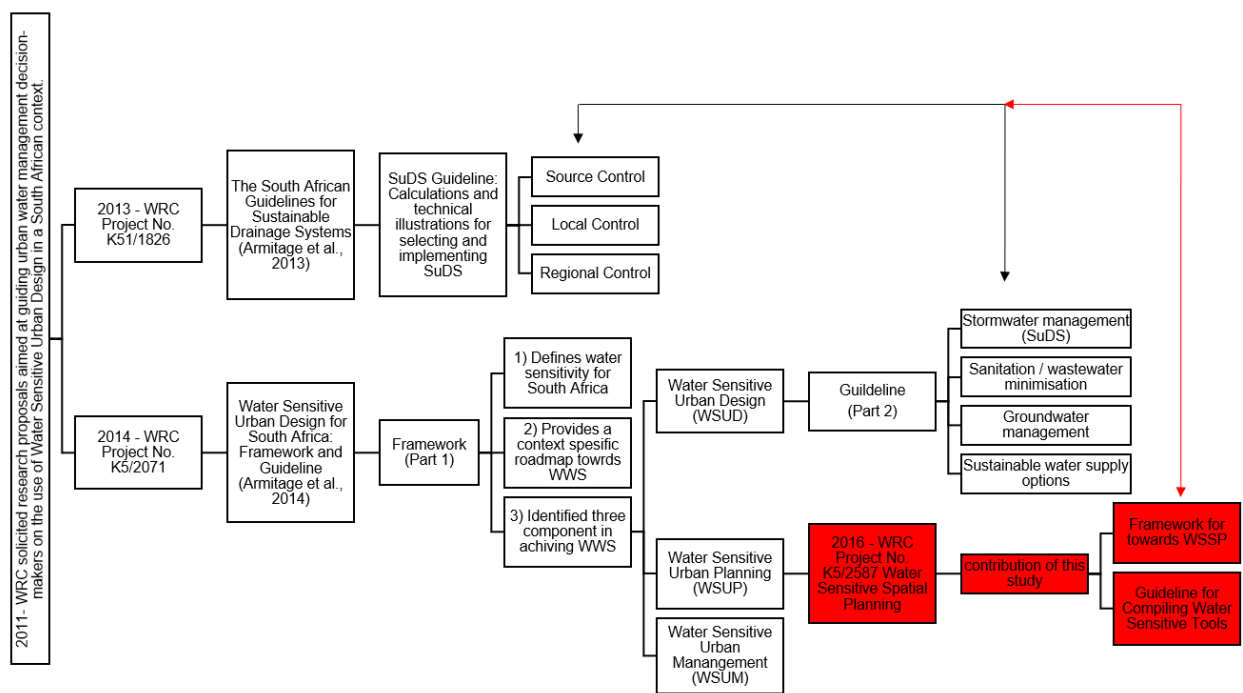


Figure 7-2: Contribution of this study to water sensitive design

Source: Own Construction (2018)

7.5 Innovation and contribution

Research Objective: Identify appropriate spatial data, resources and additional tools to assist spatial planners in developing WSSDF and WSLUS.

- Regarding spatial data, Annexure F provides a list of spatial datasets (shapefiles), the custodians of the specific data, and where the data can be accessed.

- Resources and tools to assist spatial planners in developing WSSDF and WSLUS were provided thought Chapter 4 which includes:
 - o The South African Guidelines for Sustainable Drainage Systems (WRC Project No. K5/1826) (Armitage *et al.*, 2013).
 - o The Water Sensitive Urban Design for South Africa: Framework and Guidelines (WRC Project No. K5/2071) (Armitage *et al.*, 2014).
 - o Implementation Manual for Freshwater Ecosystem Priority Areas. (WRC Report No. 1801/1/11) (Driver *et al.*, 2011).
 - o Several new methodologies for evidence based spatial modelling was provided in Chapter 5 in particular:
 - Land Use Water Consumption Model;
 - Urban Rainwater Harvesting Potential Model;
 - Land Water Quality Threats Model; and
 - Density Water Loss Model.
 - o Annexures and tables to guide the development of future WSSP and WSLUS
 - Water Sensitive Compliance analysis: SDF - Section 5.3.2.1.
 - Water Sensitive Compliance analysis: SDF - Section 5.3.2.2.
 - Annexure A Generic questions for legislation identification and assessment.
 - Annexure B Mandatory policies and plans to be prepared by government department.
 - Annexure C Generic questions for policy and plan identification and assessment.
 - Annexure D Detailed questionnaire to guide the water sensitive policy and plan assessment.
 - Annexure E Land use water quality threat rating;
 - o Framework for Framework for Water Sensitive Spatial Planning - Section 7.2
 - o Guideline for compiling Water Sensitive Tools – Section 7.3

BIBLIOGRAPHY

AFRICAN UNION COMMISSION. 2015. The African Union & Agenda 2063. Addis Ababa, Ethiopia: African Union Commission. <http://www.un.org/en/africa/osaa/pdf/au/agenda2063.pdf>
Date of access: 27 September 2016.

AECOM. 2016. Limpopo Water Management Area North Reconciliation Strategy: P WMA 01/000/00/02914/4/3 – Supporting Document 3: Socio-Economic Perspective on Future Water. Department of Water and Sanitation: Directorate: National Water Resource Planning.

AGNEW, C. & ANDERSON, W. 1992. Water in the arid realm. London: Routledge.

ALEXANDRATOS, N. & BRUINSMA, J. 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working Paper No.12-03, Rome: FAO.

ANGEL, S., PARENT, J., CIVCO, D. L. & BLEI, A. M. 2011. Making Room for a Planet of Cities, Lincoln Institute of Land Policy. https://www.lincolninst.edu/sites/default/files/pubfiles/making-room-for-a-planet-of-cities-full_0.pdf Date of access: 22 February 2016.

ANGELAKIS, A., DIALYNAS, M. & DESPOTAKIS, V. 2012. Evolution of water supply technologies in Crete, Hellas through the centuries. In: Evolution of Water Supply throughout Millennia. London, UK: IWA Publishing, 227–258.

ANGELAKIS, A. & SNYDER, S. 2015. Wastewater Treatment and Reuse: Past, Present, and Future. Water 2015, 7:4887-4895.

ANGELAKIS, A. & ZHENG, X. 2015. Evolution of Water Supply, Sanitation, Wastewater, and Stormwater Technologies Globally. Water, 7:455-463.

ARMITAGE, N., VICE, M., FISHER-JEFFES, L., WINTER, K., SPIEGEL, A., & DUNSTAN, J. 2013. Alternative Technologies for Stormwater Management. The South African Guidelines for Sustainable Drainage Systems. WRC Report No. TT 558/13. Pretoria, South Africa: Water Research Commission.

ARMITAGE, N., FISHER-JEFFER, L., CARDEN, K., WINTER, K., NAIDOO, V., SPIEGEL, A., MAUCK, B., COULSON, D. 2014. Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines. Water Research Commission Report No. TT 588/14. Pretoria, South Africa.

- ASHKENAZI, E. 2012. Ancient well reveals secrets of first Jezreel Valley farmers. <http://www.subsurfacemicrobiology.com/origins/> Date of access: 29 May 2017.
- ASHLEY, R., LUNDY, L., WARD, S., SHAFFER, P., WALKER, L., MORGAN, C., . . . MOORE, S. 2013. Water-sensitive urban design: opportunities for the UK. *Proceedings of the ICE-Municipal Engineer*, 166(2):65-76.
- ASMAL, K. 2000. Dealing with differences: The South African Experience. In: F. Boal, ed. *Ethnicity and Housing: Accommodating Differences*. England: Ashgate Publishing, 27-33.
- BAHL, R. & BIRD, R. 2016. *Decentralization and Infrastructure in Developing Countries: Reconciling Principles and Practice*, Toronto, Canada: Institute on Municipal Finance & Governance. Munk School of Global Affairs.
- BARBER, J & BARRATT, J. 1990. *South Africa's Foreign Policy: The Search for Status and Security, 1945-1988*. Cambridge: Cambridge University Press in association with the South African Institute of International Affairs.
- BARKEN, S.E. 2012. *A Primer on Social Problems*. Lardbucket.
- BATES, B. 2008. *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change. Geneva: IPCC Secretariat.
- BAYULKEN, B. & HUISINGH, D. 2015. A literature review of historical trends and emerging theoretical approaches for developing sustainable cities. *Journal of Cleaner Production*, 109:11-24.
- BECK, U. 2000. *Risk Society. Towards a New Modernity*. London: Sage.
- BENGTTSSON, L., BONNET, R.M., CALISTO, M., DESTOUNI, G., GURNEY, R., JOHANNESSEN, R., KERR, Y., LAHOZ, W.A., & RAST, M. 2014. *The Earth's Hydrological Cycle*. Netherlands: Dordrecht: Springer Netherlands.
- BESSON, J. 1569. *L'art et science de trouver les eaux et fontaines cachées sous terre autrement que par les moyens vulgaires des Agriculteurs & Architectes*. Orléans: Pierre Trepperel.
- BIODIVERSITY GIS. 2018. South African National Biodiversity Institute. <http://bgis.sanbi.org/Projects/Detail/207> Date of access: 05 December 2018.

- BIRKELAND, J. 2012. Design blindness in sustainable development: From closed to open systems design thinking. *Journal of Urban Design*, 17(2):163-187.
- BIRNER, T. 2010. Recent widening of the tropical belt from global tropopause statistics: sensitivities. *Journal of Geophysical Research* 115:D23109.
- BISWAS, A. 2004. Integrated Water Resource Management: A Reassessment. *Water International*, 29(2):248-256.
- BLACK, P. & WILIAM, D. 1998. Assessment and Classroom Learning. *Assessment in Education: Principles, Policy & Practice*, 5(1):7-74.
- BLACK, R. 2012. BBC. Science & Environment. Stockholm: Birth of the green generation. <http://www.bbc.com/news/science-environment-18315205> Date of access: 15 August 2017.
- BOOTH, D. B. & JACKSON, C. R. 1997. Urbanization of aquatic systems: degradation thresholds, stormwater detection, and the limits of mitigation. *Journal of the American Water Resources Association*, 33(5):1077-1090.
- BOUD, D. & FALCHIKOV, N. 1989. Quantitative studies of student self-assessment and peer assessment. *Higher Education*, 18(5):529–49.
- BRADLEY, R., WEERARANTNE, S. & MEDIWAKE, T. 2002. Water use projections in developing countries. *American Water Works Association*, 94(8):52-63.
- BROWN, R., KEATH, N. & WONG, T. 2008. Transitioning to Water Sensitive Cities: Ensuring Resilience through a new Hydro-Social Contract. 11th International Conference on Urban Drainage. Edinburgh, Scotland, UK, APS Group Scotland.
- BRUNDTLAND COMMISSION. 1987. *Our Common Future*. Oxford: Oxford University Press.
- CAMERON, T. & SPIES, S. 1986. The Cape from 1488 to 1854: The Forming of a New Society. In: T. a. S. S. (in Cameron, ed. *New History of South Africa in Word and Image (Afrikaans)*). Cape Town: Human & Rousseau.
- CAMP, W. G. & HEATH-CAMP, B. 2015. *Managing Our Natural Resources*. Cengage Learning.

CAPENATURE. 2014. Conserving the water factories of the Western Cape. <http://www.capenature.co.za/conserving-water-factories-western-cape/> Date of Access: 16 September 2016.

CHANGWAYS INTERNATIONAL. 2009. MauriceStrong.net. <http://www.mauricestrong.net/index.php/opening-statement> Date of Access: 25 August 2017.

CHAPIN, F.S., ZAVALA, E.S., EVINER, V.T., NAYLOR, R.L., VITOUSEK, P.M., REYNOLDS, H., HOOPER, D.U., LAVOREL, S., SALA, O.E., HOBBIE, S.E., MACK, M.C. & DIAZ, S. 2000. Consequences of changing biodiversity. *Nature*, 405(6783):234-242.

CHARLTON, S. 2008. The state of land use management in South Africa. A report as part of the Inequality and Marginalisation theme prepared for Urban Landmark and Trade and Industrial Strategies (TIPS). South Africa: Urban Landmark and Trade and Industrial Strategies.

CITY OF CAPE TOWN. 2012. City of Cape Town Green Buildings Guidelines. City of Capetown, South Africa.

CITY OF TSHWANE. 2012. Tshwane Metropolitan Spatial Development Framework 2012. Tshwane: Tshwane Metropolitan.

COBLE, C.R., MURRAY, E.G. & RICE, D.R. 1987. *Earth Science*. Englewood Cliffs: NJ: Prentice-Hall.

COGTA (COOPERATIVE GOVERNANCE AND TRADITIONAL AFFAIRS). 2016. Integrated Urban Development Framework: A new deal for South African cities and Towns. Pretoria, South Africa: COGTA.

COLVIN, C. & MURUVEN, D. 2017. Scenarios for the Future of Water in South Africa, Cape Town, South Africa: World Wide Fund - South Africa.

CRCWSC (COOPERATIVE RESEARCH CENTRE FOR WATER SENSITIVE CITIES). 2019. CRC for Water Sensitive Cities. What is a water sensitive city? <https://watersensitvecities.org.au/what-is-a-water-sensitive-city/> Date of access: 25 February 2019

DAVENPORT, T. 1989. *South Africa: A modern history*. (Second impression), Cape Town, South Africa: Southern Book Publisher.

DAVENPORT, T. & SAUNDERS, C. 2000. South Africa: A Modern History, Houndmills and New York: Macmillan Press and St Martin's Press.

DAVIES, B., O'KEEFFE, J., & SANDDON, C. 2006. River and Stream Ecosystems in Southern Africa: Predictably unpredictable. In C. Cushing, K. Cummins, & G. Minshall (Eds.), River and Stream Ecosystems of the World: With a New Introduction 537-599. University of California Press.

DAVIS, S. & DE WIESE, R. 1966. Hydrogeology, New York: John Wiley.

DAVIS, S. & ROSENLOF, K. 2012. A multi-diagnostic intercomparing of tropical width time series using reanalyses and satellite observations. *Journal of Climatology*, 25:1061-1078.

DE JONG, M., JOSS, S., SCHRAVEN, D., ZHAN, C. & WEIJNEN, M. 2015. Sustainable-smart-resilient-low carbon-eco-knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production*, 109:25-38.

DEA (DEPARTMENT OF ENVIRONMENTAL AFFAIRS). 2010. National Protected Area Expansion Strategy 2008. Department of Environmental Affairs. Pretoria, South Africa.

DEA (DEPARTMENT OF ENVIRONMENTAL AFFAIRS). 2014. Climate change adaption: a perspective on urban, rural and coastal human settlements in South Africa. Report No. 4 For the Long Term Adaption Scenarios Flagship Research Programme (LTAS), Pretoria, South African Government: Department of Environmental Affairs.

DEA (DEPARTMENT OF ENVIRONMENTAL AFFAIRS). 2015. National Biodiversity Strategy Action Plan 2015-2025. Department of Environmental Affairs. Pretoria, South Africa.

DEA (DEPARTMENT OF ENVIRONMENTAL AFFAIRS). 2016. National Protected Areas Expansion Strategy, Pretoria, South Africa: Department of Environmental Affairs.

DEAT (DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM). 2005. South Africa's National Biodiversity Strategic Action Plan. Department of Environmental Affairs and Tourism. Pretoria, South Africa.

DEAT (DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM). 2008. A National Framework for Sustainable Development in South Africa. Department of Environmental Affairs and Tourism. Pretoria, South Africa.

DEAT (DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM). 2009. National Biodiversity Framework 2008. Government Gazette, 3 August 2009. Department of Environmental Affairs and Tourism. Pretoria, South Africa.

DEWAR, D. 1998. Settlements - change and planning in South Africa since 1994. In: H. J. a. I. Vladislavic, ed. Rotterdam: Nai: Blank Architecture, Apartheid and After. 369-375.

DODDS, F., SCHNEEBERGER, K. & ULLAH, F. 2012. Review of implementation of Agenda 21 and the Rio Principles. United National Division of Sustainable Development.

DoH (DEPARTMENT OF HOUSING). 2004. Breaking New Ground: A comprehensive plan for the development of sustainable human settlements. National Department of Housing. Pretoria: Government Printer.

DONALDSON, R. & MARAIS, L. 2002. Urban Policy for urban change during the transition: An introduction, in Donaldson, R. and Marais, L. (eds.) Transforming rural and urban spaces in South Africa during the 1990s. Reform, restructuring, Africa Institute of South Africa. Pretoria, 179-204.

DPLG (DEPARTMENT OF PROVINCIAL AND LOCAL GOVERNMENT). 2001. Local Government: Municipal Planning and Performance Management Regulations. No. R. 796. Pretoria: Government Printer.

DRIAUX, D. 2016. Water supply of ancient Egyptian settlements: the role of the state. Overview of a relatively equitable scheme from the Old to New Kingdom (ca. 2543–1077 BC). *Water History*, 8:43–58.

DRIVER, A., MAZE, K., LOMBARD, A.T., NEL, J., ROUGET, M., TURPIE, J.K., COWLING, R.M., DESMET, P., GOODMAN, P., HARRIS, J., JONAS, Z., REYERS, B., SINK, K. & STRAUSS, T. 2004. South African National Spatial Biodiversity Assessment 2004: Summary Report. South African National Biodiversity Institute. Pretoria, South Africa.

DRIVER, A., NEL, J.L., SNADDON, K., MURRAY, K., ROUX, D.J., HILL, L., SWARTZ, ER., MANUEL, J., FUNKE, N. 2011. Implementation Manual for Freshwater Ecosystem Priority Areas. Water Research Commission. Report No. 1801/1/11.

DRIVER, A., SINK, K., NEL, J., HOLNESS, S., VAN NIEKERK, L., DANIELS, F., . . . MAZE, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and

ecosystems. Synthesis Report. Pretoria: South African National Biodiversity Institute and Department of Environmental Affairs.

DWA (DEPARTMENT OF WATER AFFAIRS). 1988. Report of the Director-General: Water Affairs for the Period 1 April 1987 to 31 March 1988. Pretoria, South Africa: Department of Water Affairs. Doc. No. R.P. 39/1989.

DWA (DEPARTMENT OF WATER AFFAIRS). 2010. Artificial groundwater recharge: recent initiatives in Southern Africa 2010. Department of Water Affairs. Pretoria, South Africa.

DWA (DEPARTMENT OF WATER AFFAIRS). 2011. Directorate Water Resource Planning Systems Water Quality Planning. Resource Directed Management of Water Quality. Planning Level Review of Water Quality in South Africa. Sub-series No.WQP 2.0. Pretoria, South Africa: Department of Water Affairs.

DWA (DEPARTMENT OF WATER AFFAIRS). 2013a. National Water Resource Strategy Second Edition June 2013. Water for an equitable and sustainable future. National Department of Water Affairs. Pretoria, South Africa

DWA (DEPARTMENT OF WATER AFFAIRS). 2013b. Proposed National Water Resource Strategy 2 (NWRS-2): Annexure B Understanding Water Resources. Pretoria, South Africa, July 2012: Department of Water Affairs.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 1994. 1994 White Paper on a National Water Policy for South Africa. Department of Water Affairs and Forestry. <http://www.dwa.gov.za/Documents/Policies/nwpwp.pdf> Date of access: 03 March 2017.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 2001. GNR.509 of 8 June 2001: Regulations relating to compulsory national standards and measures to conserve water. Department of Water Affairs and Forestry.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 2004a. National Water Resource Strategy. Department of Water Affairs and Forestry. Pretoria, South Africa.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 2004b. A history of the first decade of Water Services delivery in South Africa. Pretoria: Government Printer.

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY). 2010. Groundwater Strategy 2010. Department of Water Affairs and Forestry. Pretoria, South Africa.

DWS (DEPARTMENT OF WATER AND SANITATION). 2013. 2013 Green Drop Report - Executive summary. Pretoria, South Africa: Department of Water and Sanitation.

DWS (DEPARTMENT OF WATER AND SANITATION). 2014. 2014 Blue Drop Report. Pretoria, South African Government: Department of Water and Sanitation.

DWS (DEPARTMENT OF WATER AND SANITATION). 2015. Strategic Overview of the Water Service Sector in South Africa 2015. Pretoria: Department of Water and Sanitation.

DWS (DEPARTMENT OF WATER AND SANITATION). 2016a. Revised Strategic Plan (Vote 36) 2015/2016 to 2019/20. Department of Water and Sanitation. Pretoria, South Africa.

DWS (DEPARTMENT OF WATER AND SANITATION). 2016b. National Groundwater Strategy. Final Draft April 2016. Pretoria. South African Government.

DWS (DEPARTMENT OF WATER AND SANITATION). 2017a. Strategic overview of the water sector in South Africa 2017. Pretoria, South Africa: Department of Water and Sanitation: Directorate Water Services Macro Planning.

DWS (DEPARTMENT OF WATER AND SANITATION). 2017b. Draft National Water and Sanitation Master Plan. Pretoria. South Africa: Department of Water and Sanitation.

DWS (DEPARTMENT OF WATER AND SANITATION). 2018. National Integrated Water Information System. <http://niwis.dws.gov.za/niwis2/DocumentManagement> Date of access: 20 May 2018.

EDWARDS, K., CLASSEN, G. & SCHROTEN, E. 1983. The hydrological cycle and its components. In: The water resource in tropical Africa and its exploitation. s.l.: International Livestock Centre for Africa, 20-40.

EPA (ENVIRONMENTAL PROTECTION AGENCY). 1999. Combined Sewer Overflow Management Fact Sheet: Sewer Separation, Washington, D.C: Municipal Technology Branch, United States Environmental Protection Agency, Office of Water.

EPA (ENVIRONMENTAL PROTECTION AGENCY). 2005. Using Smart Growth Techniques as Stormwater Best Management Practice (1807-T). Washington DC: United States Environmental Protection Agency.

ERSKINE, S., BOOTH, A. & STILL, D. 2011. Stormwater ingress in South African sewer systems understanding the problem and dealing with it. WRC Report No. 1731/1/11, Pretoria, South Africa: Water Research Commission.

ETHEKWINI MUNICIPALITY. 2013. eTihekwini City Densification Strategy, eTihekwini: eThekwini Municipality.

EVERATT, D. & SMITH, M. 2008. The Department of Social Development's study on the ISRDP and URP. South Africa. Department of Social Development.

FABOS, J. 2004. Greenway planning in the United States: its origins and recent case studies. *Landscape and Urban Planning*, 68:321-342.

FALKENMARK, M. & WIDSTRAND, C. 1992. Population and water resources: a delicate balance. *Population Bulletin*, 47(3):2-35.

FALKENMARK, M., & LINDH, G. 1974. How can we cope with the water resources situation by the year 2015? *Ambio*. 3(3/4):114–122.

FAO (FOOD AND AGRICULTURE ORGANIZATION). 2016a. AQUASTAT website. Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/nr/water/aquastat/water_use/index.stm Date of access: 3 August 2017.

FAO (FOOD AND AGRICULTURE ORGANIZATION). 2016b. AQUASTATS - Average annual precipitation. http://www.fao.org/nr/water/aquastat/maps/Precipitation_eng.pdf Date of access: 06 May 2017.

FLETCHER, T., SHUSTER, W., HUNT, W., ASHLEY, R., BUTLER, D., ARTHUR, S., . . . VIKLANDER, M. 2015. SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage. *Urban Water Journal*, 12(7):525-542.

FORSTER, C., LEON, B. & MENGUELE, F. 2006. Sharing learning from a DPLG/GTZ/EC urban renewal nodes support initiative. http://www1.durban.gov.za/durban/government/abms/index_html/conference/clive_forster/ Date of Access: 07 October 2017.

FORSTER, P., RAMASWAMY, P., ARTAXO, T., BERNTSEN, R., BETTS, D., FAHEY, J., . . . DORLAND, R. V. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In S. Solomon, Q. Qin, M. Manning, Z. Chen, M. Marquis, K. Averyt, . . . H. Miller (Eds.), *Climate*

Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 131-234.

FU, Q., JOHANSON, C., WALLACE, J. & REICHLER, T. 2006. Enhanced mid-latitude tropospheric warming in satellite measurements. *Science*, 312:1179.

GALDBLATT, A. 2014. Agriculture: Facts and Trends in South Africa. WWF-SA.

GCIS (GOVERNMENT COMMUNICATION AND INFORMATION SYSTEM). 2009. SA Yearbook 2008/09. Pretoria: Government Communication and Information System (GCIS).

GELDENHUYS, D. 1990. *Isolated States: A Comparative Analysis*. Johannesburg: Jonathan Ball Publishers.

GEORG, S. 2015. Building sustainable cities: tools for developing new building practices. *Global Networks*, 15(3):325-342.

GILIOMEE, H. & MBENGA, B. 2007. *A new history of South Africa*. Cape Town, South Africa.

GIOVANNI, D., ANTONIOU, G., FARDIN, H., EL-GOHARY, F., ZHENG, X., REKLAITYTE, I., . . . ANGELAKIS, A. 2014. The Historical Development of Sewers Worldwide. *Sustainability*, 6:3936-3974. doi:10.3390/su6063936

GLEICK, P. H. 1996. Water resources ed. by S. H. Schneider,. In: S. H. Schneider, ed. In *Encyclopedia of Climate and Weather*. New York: Oxford University Press, 817-823.

GMELIN, S. G. 1774. *Reise durch Russland zur Untersuchung der drei Naturreiche*. (Acad. Sci. St. Petersburg), part 3 (Concerns chiefly the natural history of the Caspian basin; very little about water.) ed. St. Petersburg: Acad. Sci. St. Petersburg, 231-508.

GOGA, S & PEGRAM, G. 2014. A review of integrated planning in South Africa. Understanding the Food Energy-Water Nexus. South Africa: WWF-SA.

GOVERNMENT OF SOUTH AFRICA, 1961. The conservation of mountain catchments in South Africa. Report of the inter-departmental committee. Pretoria, South Africa, Department of Agricultural Technical Services.

GOVERNMENT OF SOUTH AFRICA. 1970. Report of the Commission of Inquiry into Water Matters, Pretoria: Government Printers. Doc. No. R.P. 34/1970

GWP (GLOBAL WATER PARTNERSHIP) 2000. Integrated Water Resource Management: Background and Technical Paper No. 4. <http://www.gwp.org/en/Search-result/?q=background+paper+no+4> Date of Access: 05 September 2016

HAIRSTON, J. E. & STRIBLING, L. 2001. How Nature Recycles and Purifies Water: The Hydrological Cycle. Alabama Cooperative Extension System.

HALLEY, E. 1687. An estimate of the quantity of water raised out of the sea by the warmth of the sun. London: Phil. Trans. R. Soc, 16(18).

HARDING, R. 2006. Ecological sustainable development: origins, implementation and challenges. *Desalination*, 187:229-239.

HARDOY, J., MILTIN, D. & SATTERTHWAITE, D. 2001. Environmental Problems in an Urbanizing World: Finding Solutions for Cities in Africa, Asia and Latin America., London: Earthscan.

HEFFERNAN, O. 2016. The Mystery of the Expanding Tropics. *Nature*, 530(20):20-22.

HERBERT, M. 1983. The Daring experiment: Social scientist and land-use planning in 1940's Britain. *Environment and Planning*: 3-17.

HILLEL, D. 1971. Soil and water: Physical principles and processes. New York: Academic Press.

HILLEN, M., & DOLMAN, N. 2015. Towards Water Adaptive Cities. World Engineers Summit on Climate Change.

HOBBS, R., ARICO, S., ARONSON, J., BARON, J., BRIDGEWATER, P., CRAMER, V., . . . ZOBEL, M. 2006. Novel ecosystems: theoretical and management aspects of the new ecological world order. *Global Ecology and Biogeography*, 15(1):1– 7. doi:10. 1111/j.1466-822X.2006.00212.x

HORTON, R. 1933. The role of infiltration in the hydrological cycle. *Trans 14th. Ann. Meeting Am. Geophys Un*:446-460

HU, Y. & FU, Q. 2007. Observed poleward expansion of the Hadley circulation since 1979. *Atmospheric Chemistry and Physics*, 7:5229–5236.

HU, Y., ZHOU, C. & LIU, J. 2011. Observational evidence for the poleward expansion of the Hadley circulation. *Advanced Atmospheric Science*, 28:33–44.

HUDSON, R. D., ANDRADE, M. F., FOLLETTE, M. B. & FROLOV, A. D. 2006. The total ozone field separated into meteorological regimes – Part II: Northern Hemisphere mid-latitude total ozone trends. *Atmospheric Chemistry and Physics*, 6:5183–5191.

IPPC (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE). 2014. *Climate Change 2014. Synthesis Report. Summary for Policy Makers*. [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IUCN (INTERNATIONAL UNION FOR CONSERVATION OF NATURAL RESOURCES). 1980. *World Conservation Strategy*. http://earthmind.org/sites/default/files/1980-IUCN-WorldConservationStrategy_0.pdf Date of Access: 12 January 2016.

IWMI (INTERNATIONAL WATER MANAGEMENT INSTITUTE). 2007. *International Water Management Institute. Comprehensive Assessment of Water Management in Agriculture*. Colombo, Sri Lanka: World Water Week in Stockholm.

JANSEN, M. 1989. Water Supply and Sewage Disposal at Mohenjo-Daro, *World Archaeology*. *World Archaeology*, 21(2):177-192.

JETZ, W., WILCOVE, D., & DOBSON, P. 2007. Projected impacts of climate change and land use change on the global diversity of birds. *PLoS Biol*, 5(6):1211-1219.

KELLETT, L., & JONES, E. 2016. *Settlement Ecology of the Ancient Americas*. Taylor & Francis.

KING, J., MITCHELL, S. & PIENAAR, H. 2011. *Water Supply and Demand*. In J. King, & H. Pienaar (Eds.), *Sustainable Use Of South Africa's Inland Waters*. Water Research Commission. WRC Report Number TT491/11: 1-6

KIRKBY, J., O'KEEFE, P. & TIMBERLAKE, L. 1999. *Sustainable development: an introduction*. In: J. Kirkby, P. O'Keefe & L. Timberlake, eds. *The Earthscan Reader in Sustainable Development*. London: Earthscan: 1-4.

- KORGAONKAR, Y., BURNS, S. I., GUERTIN, P. D., GOODRICH, D., UNKRICH, C. L., BARLOW, J. E., & KEPNER, W. G. 2014. Representing Green Infrastructure Management Techniques in Arid and Semi-arid Regions: Software Implementation and Demonstration using the AGWA/KINEROS2 Watershed Model. Office of Research and Development. Washington, DC 20460: U.S. Environmental Protection Agency.
- KOUTSOYIANNIS, D., ZARKADOULAS, N., ANGELAKIS, A., & TCHOBANOGLOUS, G. 2008. Urban water management in ancient Greece: Legacies and lessons. *ASCE J. Water Resource Planning & Management*, 134:45–54.
- LAMBIN, E., TURNER, B., GEIST, H., AGBOLA, S., A, A., BRUCE, J., . . . XU, J. 2001. The causes of land-use and land-cover change: Moving beyond the myths. *Global Environmental Change*, 11(4):261-269.
- LARSON, P. & LOHRENGEL II, C. 2011. A new Tool for Climatic Analysis Using the Koppen Climate Classification. *Journal of Geography*, 110(3):120-130.
- LATEGAN, L. 2017. Informality and sustainability: reflecting on South Africa’s informal backyard rental sector from a planning perspective. Potchefstroom: NWU. (Thesis – PhD).
- LE GATES, R “Teaching Spatially Integrated Research Methods” (Unpublished contribution delivered at the 25th Annual ESRI International User Group Conference in California July 2005).
- LEHMANN, S. 2010. Green Urbanism: Formulation a Series of Holistic Principles. *Surveys and Perspectives Integration Environment and Society*, 3(2):1-16.
- LEOPOLD, L.B. 1968. Hydrology for urban land planning: A guidebook on the hydrologic effects of urban land use. Washington (DC): US Geological Survey.
- LEPHALALE LOCAL MUNICIPALITY. 2005. Lephalale Local Municipality Water and Sanitation Services By-law. Lephalale, South Africa: Lephalale Local Municipality.
- LEPHALALE LOCAL MUNICIPALITY. 2011a. Lephalale Local Municipality Waste Management By-Law. Lephalale, South Africa: Lephalale Local Municipality.
- LEPHALALE LOCAL MUNICIPALITY. 2011b. Lephalale Local Municipality Stormwater By-law. Lephalale, South Africa: Lephalale Local Municipality.

LEPHALALE LOCAL MUNICIPALITY. 2017a. Lephale Local Municipality Spatial Development Framework. Lephale Local Municipality Department of Urban Planning.

LEPHALALE LOCAL MUNICIPALITY. 2017b. Lephale Spatial Planning and Land Use Management By-law. Lephale, South Africa: Lephale Local Municipality.

LEVINE, X. 2017. Yale Climate and Energy Institute. What Causes Dryness in Earth's Subtropics? <http://climate.yale.edu/perspectives/what-causes-dryness-earths-subtropics> Date of access: 23 May 2017.

LEXICO. 2019. LEXICO Dictionary Powered by Oxford. <https://www.lexico.com/en/definition/evidence-based> Date of Access: 13 of June 2019.

LIMPOPO PROVINCIAL GOVERNMENT. 2003. Limpopo Environmental Management Act 7 of 2003. Polokwane, South Africa: Limpopo Provincial Government.

LIMPOPO PROVINCIAL GOVERNMENT. 2006. Limpopo Housing Act no. 2 of 2006. Polokwane, South Africa: Limpopo Provincial Government.

LIMPOPO PROVINCIAL GOVERNMENT. 2015. Limpopo Development Plan, s.l.: Limpopo Provincial Government: Office of the Premier.

LIMPOPO PROVINCIAL GOVERNMENT. 2016. Limpopo Spatial Development Framework, s.l.: Office of the Premier.

LONG, B. 2000. International Environmental Issues and the OECD 1950-2000: An Historical Perspective. Paris: Organization for Economic Cooperation and Development.

LU, J., DESER, C. & REICHLER, T. 2009. Cause of the widening of the tropical belt since 1958. Geophysical Research Letters, 36, L02803.

LUCAS, C., TIMBAL, B. & NGUYEN, H. 2014. The expanding tropics: a critical assessment of the observational and modelling studies. WIREs Climate Change, 5:89-112.

LVOVITCH, M. 1970. World Water Balance (General Report). Symposium on the World Water Balance. International Association of Hydrological Sciences, 2(93):401-415.

MACFARLANE, D., BREDIN, I., ADAMS, J., ZUNGU, M., BATE, G., & DICKENS, C. 2014. Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries.

Consolidated Report. WRC Report No. TT 610/14. Pretoria, South Africa: Water Research Commission.

MACKENZIE, M. 2009. Water rights in NSW: properly property? Sydney Law Review, 3(31):443-463.

MAGUBANE, B. 1996. The Making of a Racist State: British Imperialism and the Union of South Africa, Africa World Press: Trenton, 1875-1910.

MAKEPEACE, D., SMITH, D., & STANLEY, S. 1995. Urban stormwater quality: Summary of contaminant data. Critical Reviews in Environmental Science and Technology, 25(2):93-139.

MALIVA, R. & MISSIMER, T. 2012. Arid Lands Water Evaluation and Management. Berlin, Heidelberg: Springer-Verlag.

MANDELA, N. 1994. The Reconstruction and Development Programme (RDP) Policy Framework. Republic of South Africa.

MARIOTTE, E. 1686. Traité du mouvement des eaux et d'autres corps fluides. ed. Paris: E. Michallet.

MARSALEK, J., JIMÉNEZ-CISNEROS, B., MALMQUIST, P., KARAMOUZ, M., GOLDENFUM, J., & CHOCAT, B. 2006. Urban water cycle processes and interactions. France: International Hydrological Programme (IHP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

MAYS, L. M. 2010. Ancient Water Technologies. Dordrecht; London; New York: Springer.

MAYS, L., KOUTSOYIANNES, D., & ANGELAKIS, N. 2007. A Brief History of Urban Water Supply in the Antiquity. Water Science & Technology Water Supply.

MCDONALD, R., DOUGLAS, I., REVENGA, C., HALE, R., GRIMM, N., GRONWALL, J., & FEKETE, B. 2011. Global Urban Growth and the Geography of Water Availability, Quality, and Delivery. Ambio, 40:437-447

MCKENZIE, R., & SEAGO, C. 2005. Benchmarking of leakage from water reticulation systems in South Africa. WRC Report No. TT 244/05. Pretoria: Water Research Commission.

MEADOWS, D. H., MEADOWS, D. I., RANDERS, J. & BEHRENS, W.W. 1972. Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind. New York: Universe Books.

MEDEMA, W. MCLINTOSH, B. & JEFFERY, P. 2008. From Promise to Practice: a critical Assessment of Integrated Water Resource Management and Adaptive Management Approaches in the. Ecology and Society, 2(13).

MILLENNIUM ECOSYSTEM ASSESSMENT. 2005. Ecosystem and human well-being: biodiversity synthesis, Washington DC: World Resource Institute.

MOGALAKWENA LOCAL MUNICIPALITY. 2006. Mogalakwena Local Municipality Water-by Law. South Africa: Mogalakwena Local Municipality.

MOGALAKWENA LOCAL MUNICIPALITY. 2009. Mogalakwena Spatial Development Framework. South Africa, Potgietersrus: Mogalakwena Local Municipality.

MOGALAKWENA LOCAL MUNICIPALITY. 2016. Mogalakwena Spatial Planning and Land Use Management By-Laws. South Africa: Mogalakwena Local Municipality.

MOGALAKWENA LOCAL MUNICIPALITY. 2018. Mogalakwena Local Municipality Integrated Development Plan 2018/2019. South Africa, Potgietersrus: Mogalakwena Local Municipality.

MOREL-SEYTOUX, H. & KHANJI, J. 1974. Derivation of an equation in infiltration. Water Resour. Res, 10(4):795-800.

MULLEN, K. 2012. Information on Earth's water. <http://www.ngwa.org/Fundamentals/teachers/Pages/information-on-earth-water.aspx> Date of Access: 22 April 2017.

NACE, R. 1971. A Scientific framework of world water balance. UNESCO Tech. Papers Hydrol, (7).

NASA. 2003. Weighing Earths water from space. <https://earthobservatory.nasa.gov/Features/WeighingWater/> Date of access: 07 August 2017

NATIONAL DEVELOPMENT AND PLANNING COMMISSION. 1999. Draft Green Paper on Development and Planning. Document DPC 4/99, Pretoria. Republic of South Africa: National Development and Planning Commission.

NATIONAL PLANNING COMMISSION. 2011. National Development Plan Vision 2030. Pretoria, South Africa: The Presidency of the Republic of South Africa.

NATIONAL RESEARCH COUNCIL. 2006. Committee on Public Water Supply Distribution, National Research Council. Drinking Water Distribution System: Assessing and Reducing risks. Washington, D.C: National Academic Press.

NEL, J. & DRIVER, A. 2015. National River Ecosystem Accounts for South Africa. Discussion document for Advancing SEEA Experimental Ecosystem Accounting Project. Pretoria: South African National Biodiversity Institute.

NEL, J., COLVIN, C., LE MAITRE, D., SMITH, J., & HAINES, I. 2013. South Africa's Strategic Water Source Areas. Pretoria, South Africa: WWF-South Africa.

NEL, J., DRIVER, A., STRYDOM, W., MAHERRY, A., PETERSEN, C., HILL, L., . . . SMITH-ADAO, L. 2011. Atlas of Freshwater Ecosystems Priority Areas in South Africa: Map to support sustainable development of water resources. WRC Report No. TT 500/11. Pretoria: Water Research Commission.

NEL, M. 2017. Groundwater: The myths, the truths and the basics. Pretoria, Water Research Commission.

NEL, V. 2016. SPLUMA, Zoning and Effective Land Use Management in South Africa. Urban Forum, 27(1):79-92.

O'MALLEY, P. 2016. Nelson Mandela Centre of Memory. <https://www.nelsonmandela.org/omalley/index.php/site/q/03lv01538/04lv01646/05lv01758.htm>
Date of access: 10 February 2016

OOSTHUIZEN, K. 2000. Demographic changes and sustainable land use in South Africa. Genus, 56 (No.3/4):81-107.

ORANJE, M., & MERRIFIELD, A. 2010. National Spatial Development planning in South Africa 1930-2010: An introductory comparative analysis. SSB/TRP/MDM, 56:29-45.

PAKENHAM, T. 1986. The Second Anglo-Boer War, 1899-1902 (Afrikaans). In T. a. in Cameron (Ed.), New History of South Africa in Word and Image (Afrikaans). Cape Town: Human & Rousseau.

- PALISSY, B. 1580. Discours admirables de la nature des eaux et fontaines tant naturelles qu'artificielles. Paris.
- PARNELL, S & MABIN, A. 1995. Rethinking Urban South Africa. *Journal of South Africa Studies*, 1(21):39-61.
- PARNELL, S. & PIETERSE, E. 2010. The 'right to the city': institutional imperatives of a developmental state. *International Journal of Urban and Regional Research*, 34(1):146-162.
- PEARSON, S. 2012. Colonialism and the African experience. In: V. Khapoya, ed. *The African experience*. New York: Longman: 99-138.
- PEET, R. 2002. Ideology, Discourse, and the Geography of Hegemony: From Socialist to Neoliberal Development in Post-apartheid South Africa. *Antipode*, 1(34).
- PERLMAN, H. 2016. The USGS Water Science School. The World's Water. <https://water.usgs.gov/edu/earthwherewater.html> Date of access: 04 August 2017.
- PERRAULT, P. 1674. De l'origine des fontaines. Paris: Pierre Le Patit, Imprimeur & Libraire.
- PETER, R. & COX, F. 1954. A general view of the inaugural meeting of the World Population Conference in the F.A.O. Building at Rome. *Eugenics Review*, XLVI. 4:204-211.
- PHILIP, J. 1969. Theory of infiltration. *Adv. Hydrosci*, 5:215-296.
- POSTEL, S.L., DAILY, G.C., & EHRLICH, P.R. 1996. Human appropriation of renewable fresh water. *Science*, 271:785-788.
- PUBLIC SERVICE COMMISSION. 2010. An Evaluation of Integration and Coordination in the Integrated Sustainable Rural Development Programme. Pretoria, Government Printer.
- QUENTAL, N. & LOURENCO, J. 2012. References, authors, journals and scientific disciplines underlying the sustainable development literature: a citation analysis. *Scientometrics*, 90:361–381.
- QUENTAL, N., LOURENCO, J. M. & DA SILCA, F. N. 2009. Sustainable Development Policy: Goals, Targets and Political Cycles. *Sust. Dev*, 19:15-29.
- RAMSAR CONVENTION SECRETARIAT. 2016. An Introduction to the Ramsar Convention on Wetlands, Gland, Switzerland: Ramsar Convention Secretariat.

RDLR (DEPARTMENT OF RURAL DEVELOPMENT AND LAND REFORM). 2014a. Towards A Rural Land Use Management Framework in South Africa. A review of Literature. Pretoria, Government Printer.

RDLR (DEPARTMENT OF RURAL DEVELOPMENT AND LAND REFORM). 2014b. SDF Guideline. Pretoria, South Africa: Department of Rural Development and Land Reform.

RDLR (DEPARTMENT OF RURAL DEVELOPMENT AND LAND REFORM). 2017. Land Use Scheme Guidelines, Pretoria, South Africa: Department of Rural Development and Land Reform.

REGISTER, R. 1987. Ecocity Berkeley: building cities for a healthy future. s.l.: North Atlantic Books.

REPUBLIC OF SOUTH AFRICA. 1903. Transvaal Ordinance Establishing Municipalities. (Ordinance no. 58 of 1903). Pretoria: Government Printer.

REPUBLIC OF SOUTH AFRICA. 1909. The Union of South Africa Act. (Act no. 2 of 1909). <https://www.sahistory.org.za/archive/union-south-africa-act-1909> Date of Access 03 June 2017.

REPUBLIC OF SOUTH AFRICA. 1912. Irrigation and Conservation of Waters Act. (Act no. 8 of 1912). Pretoria: Government Printer.

RODÀ, I. 2016. National Geographic <http://www.nationalgeographic.com/archaeology-and-history/magazine/2016/11-12/roman-aqueducts-engineering-innovation/> Date of Access: 08 February 2017.

ROSE, S., & PETERS, N. E. 2001. Effects of urbanization on streamflow in the Atlanta area (Georgia, USA): A comparative hydrological approach. *Hydrological Processes*, 15(8):1441-1457. doi:10.1002/hyp.218.

ROSER, M., & ORITIZ-OSPINA, E. 2018. World Population Growth. <https://ourworldindata.org/world-population-growth> Date of access: 27 June 2018

ROSS, R. 1999. A Concise History of South Africa. Cambridge: Cambridge University Press.

ROWLSTON, B. 2011. Water Law in South Africa: From 1652 to 1998 and beyond. In: J. King & H. Pienaar, eds. Sustainable use of South Africa's inland waters. Republic of South Africa: Water Research Commission: 19-48.

ROWLSTON, B., & SCHREINER, B. 2011. Institutional arrangement for the protection of aquatic ecosystems. In J. King, & H. Pienaar (Eds.), Sustainable Use of South Africa's Inland Waters. Republic of South Africa: Water Research Commission TT 49/11: 49-79

SAAD, R., KOELLNER, T., & MARGNI, M. 2013. Land use impacts on freshwater regulation, erosion regulation, and water purification: a spatial approach for a global scale level. *Int J Life Cycle Assess*, 18:1253-1264.

SACN (SOUTH AFRICA CITIES NETWORK). 2004. State of South African Cities Report 2004. South Africa Cities Network. Johannesburg, South Africa.

SACN (SOUTH AFRICA CITIES NETWORK). 2016. State of South African Cities Report 2016. South Africa Cities Network. Johannesburg, South Africa.

SANBI (SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE). 2014a. Biodiversity mainstreaming toolbox for land-use planning and development in Gauteng. Compiled by ICLEI-Local Government for sustainability. Pretoria, South Africa.

SANBI (SOUTH AFRICA NATIONAL BIODIVERSITY INSTITUTE). 2014b. A Framework for Investing in Ecological Infrastructure in South Africa. South Africa: South African National Biodiversity Institute.

SANBI (SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE). 2016. National Biodiversity Assessment 2011. <http://biodiversityadvisor.sanbi.org/planning-and-assessment/national-biodiversity-assessment-nba-2011/> Date of access: 24 November 2016.

SARNI, W. 2011. Corporate Water Strategies. Washington, DC: Earthscan LLC.

SATTERTHWAITE, D. 2007. United Nations Expert Group Meeting on Population Distribution, Urbanization, Internal Migration and Development. Climate Change and Urbanization: Effects and implications for urban governments, New York: United Nations.

SCHULZE, R. 2011. South Africa: A Brief Overview. In: R. Schulze, ed. A 2011 perspective on climate change and the South African water sector. WRC Report TT 518/12. Pretoria, South Africa: Water Research Commission:7-12.

SEAGER, R., TING, M., HELD, I., KUSHNIR, Y., LU, J., VECCHI, G., . . . NAIK, N. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. *Science*, 316:1181-1184.

SERRAO-NEUMANN, S., RENOUF, M., KENWAY, S., & CHOY, D. 2017. Connecting land-use and water planning: Prospects for an urban water metabolism approach. *Cities*, 13-27. <http://dx.doi.org/10.1016/j.cities.2016.07.003> Date of access: 10 December 2016

SHARIFI, A., & MURAYAMA, A. 2013. A critical review of seven selected neighbourhood sustainability assessment tools. *Environmental Impact Assessment Review*, 73-87.

SHIKLOMANOV, I. 1993. Worlds freshwater resource. In: G. P. H, ed. *Water in Crisis: A guide to the Worlds Fresh Water Resources*. New York: Oxford University Press: 3-5.

SHOWERS, K. 1996. Colonial and Post-apartheid Water Projects in Southern Africa: Political Agendas and Environmental Consequences. Paper presented at the African Studies Association meetings, San Francisco, California, November 1996. C.

SITKO, N. 2005. Urban growth boundaries: economic development tool or unwanted interference? <http://www.umich.edu/~econdev/urbanbound/> Date of Access: 27 September 2016.

SOUTH AFRICA. 1913. Native Land Act. (Act no. 27 of 1913). Pretoria: Government Printer.

SOUTH AFRICA. 1923. Natives Urban Areas Act. (Act no. 21 of 1923). Pretoria: Government Printer.

SOUTH AFRICA. 1936. Native Trust and Land Act. (Act no. 18 of 1936). Pretoria: Government Printer.

SOUTH AFRICA. 1950. Population Restriction Act of 1950. Pretoria: Government Printer.

SOUTH AFRICA. 1956. Water Act. (Act no. 54 of 1956). Pretoria: Government Printer.

SOUTH AFRICA. 1993. Interim Constitution of the Republic of South Africa (Act no. 200 of 1993) GN. 15466. Pretoria: Government Printer

SOUTH AFRICA. 1995. Development Facilitation Act. (Act no 67 of 1995). Pretoria: Government Printer

SOUTH AFRICA. 1996a. Constitution of the Republic of South Africa Act. (Act 108 of 1996). Pretoria: Government Printers.

SOUTH AFRICA. 1996b. Department of Finance. Growth, Employment and Redistribution: a macroeconomic strategy, Pretoria: Government Printer.

SOUTH AFRICA. 1997a. Water Service Act (Act no. 108 of 1997). Pretoria: Government Printers.

SOUTH AFRICA. 1997b. National Housing Act. (Act no. 107 of 1997). Pretoria: Government Printer.

SOUTH AFRICA. 1998a. National Water Act (Act No. 36 of 1998). Pretoria: Government Printers.

SOUTH AFRICA. 1998b. National Environmental Management Act (Act no. 107 of 1998). Pretoria: Government Printer.

SOUTH AFRICA. 2000. Municipal Systems Act. (Act no. 32 of 2000). Pretoria: Government Printers.

SOUTH AFRICA. 2001. Department of Agriculture and Land Affairs. White Paper on Spatial Planning and Land Use Management, Pretoria: Government Printer.

SOUTH AFRICA. 2002. Disaster Management Act (Act no. 57 of 2002). Pretoria, South Africa: Government Printers.

SOUTH AFRICA. 2003. National Environmental Management: Protected Areas Act. (Act no. 57 of 2003). Pretoria: Government Printers.

SOUTH AFRICA. 2004a. National Environmental Management: Biodiversity Act. (Act no. 10 of 2004). Pretoria: Government Printers.

SOUTH AFRICA. 2004b. Local Government: Municipal Finance Management Act. (Act no. 56 of 2004). Pretoria, South Africa: Government Printers.

SOUTH AFRICA. 2008. National Environmental Waste Act (Act no. 59 of 2008). Pretoria, South Africa: Government Printers.

SOUTH AFRICA. 2009. National Land Transportation Act (Act no. 5 of 2009). South Africa: Government Printers.

SOUTH AFRICA. 2013. Spatial Planning and Land Use Management Act. (Act No. 16 of 2013). Republic of South Africa: Government Gazette.

SOUTH AFRICA. 2018. Draft National Spatial Development Framework 2018. Department of Rural Development and Land Reform.

STATS SA (STATISTICS SOUTH AFRICA). 1998. 1996 Population census. Statistics South Africa <https://apps.statssa.gov.za/census01/Census96/HTML/default.htm> Date of Access 05 October 2016.

STATS SA (STATISTICS SOUTH AFRICA). 2011. Statistics South Africa. Community Survey 2016 Statistical release. P0301. Pretoria: Statistics South Africa.

STATS SA (STATISTICS SOUTH AFRICA). 2016. Statistics South Africa. Community Survey 2016 Statistical release. P0301. Pretoria: Statistics South Africa.

STRAUSS, M. & LIEBENBERG, S. 2014. Contested spaces: Housing rights and evictions law in post-apartheid South Africa. *Planning Theory*, 13(4):428-448.

SUSTAINABLE CITIES INSTITUTE. 2012. Land use. The National League of Cities. http://www.sustainablecitiesinstitute.org/Documents/SCI/Topic_Overviews/Land%20Use%20-%20Full%20OverviewNew_NLC.pdf Date of Access: 25 September 2016.

SWITCH (SUSTAINABLE WATER MANAGEMENT IMPROVES TOMORROW'S CITIES' HEALTH). 2011. Training Kit. Integrated Urban Water Management in the city of the future. ICLEI European Secretariat GmbH.

TEWARI, D. 2008. A detailed analysis of the evolution of water rights in South Africa: An account of three and a half centuries from 1652 AD to present. School of Economics and Finance, University of KwaZulu-Natal. *Water SA* Volume 35(5):693-710

THE PRESIDENCY. 2003. National Spatial Development Perspective. Spatial Guidelines for Infrastructure Investment and Development. The Presidency, Policy Co-ordination and Advisory Services. Pretoria: Government Printer.

THE PRESIDENCY. 2005. Accelerated and Shared Growth Initiative for South Africa. Pretoria: Government Printer.

THE PRESIDENCY. 2006. National Spatial Development Perspective (NSDP). The Presidency. Chief Policy Analyst: Planning, Policy Coordination and Advice Services. Pretoria: Government Printer.

THE PRESIDENCY. 2009. Medium-Term Strategic Framework 2009-2014. The Presidency of the Republic of South Africa. Pretoria: Government Printers.

THE PRESIDENCY. 2012. National Development Plan 2030: Our future - make it work. The Presidency: National Planning Commission. Pretoria, South Africa.

THOMPSON, H., STIMIE, C., RICHTERS, E., & PERRET, S. 2001. Policies, legislation and organizations related to water in South Africa with special reference to the Olifants Basin. Working Paper No. 18. Colombo: International Water Management Institute.

THOMPSON, L., & LAMAR, H. 1981. The Frontier in History: The North American and Southern African Compared. In H. a. Lamar (Ed.). New Haven and London: Yale University Press.

THOMPSON, R. D. 1975. The climatology of arid world. University of Reading. UK, Department of Geography Paper No. 35.

THOMSON-SMEDDLE, L. & ROUX, J. 2016. Sustainable Neighbourhood Design Manual. Sustainability institute.

TURNER, R. 1988. Sustainable Environmental Management: Principles and Practice. s.l.: Belhaven. P.

TUOK, I. 2012. Urbanisation and Development in South Africa: Economic imperatives, spatial distortions and strategic responses. London, UK: Human Settlements Group. International Institute for Environment and Development (IIED)

TUOK, I. & BOREL-SALADIN, J. 2014. Is urbanisation in South Africa on a sustainable trajectory? Development Southern Africa, 31(5):675–691.

TURTON, A. & MEISSNER, R. 2015. The Hydrosocial Contract and its Manifestation in Society: A South African Case Study. African Water Issues Research Unit (AWIRU). Pretoria, South Africa.

TURTON, A., MEISSNER, R., MAMPANE, P., & SEREMO, R. 2004. A Hydrological history of South Africa's international river basins. WRC Report No. 1220/1/04. Pretoria, South Africa: WRC.

TURTON, A.R., & OHLSSON, L. 1999. Water Scarcity and Social Adaptive Capacity: Towards an Understanding of the Social Dynamics of Managing Water Scarcity in Developing Countries. Paper presented in Workshop No. 4: Water and Social Stability of the 9th Stockholm Water Symposium "Urban Stability through Integrated Water-Related Management", hosted on 9-12 August by the Stockholm Water Institute (SIWI) in Stockholm, Sweden.

TYRWHITT, T. 1933. The Athens Charter, 1933. Congress Internationaux d'Architecture moderne (CIAM), Paris, France: Harvard University. The Library of the Graduate School of Design.

UN DESA (UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION). 2015. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/PWP.241. https://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf Date of access: 8 May 2018.

UN DESA (UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION). 2018. World Urbanisation Prospects 2018: Key Facts. United Nations <https://population.un.org/wup/Publications/Files/WUP2018-KeyFacts.pdf> Date of access: 8 May 2018.

UNEP (UNITED NATIONS ENVIRONMENT PROGRAMME). 1974. United Nations Environmental Programme - the Cocoyoc Declaration Adopted by the Participants in the UNEP/UNCTAD Symposium on 'Pattern of Resource Use, Environment and Development Strategies, held at Cocoyoc, Mexico, from 8-10 October 1974. A/C.2/292. , s.l.: Declaration printed in full in International Organisation 29 (Summer 1975): 893-901, and in UNEP Executive Series, In Defense of the Earth: The Basic Texts on Environment.

UNEP (UNITED NATIONS ENVIRONMENT PROGRAMME). 2002. Global Environment Outlook 3: Past, Present and Future Perspectives. Volume 3 of GEO report series ed. Earthscan.

UNESCO (UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION). 1993. The Biosphere Conference, 25 years later, Paris, France: United Nations Educational, Scientific and Cultural Organisations.

UNESCO (UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION). 2012. Managing water under uncertainty and risk. The United Nations World Water Development Report 4. Paris: United Nations Educational, Scientific and Cultural Organization

UN-HABITAT. 2013. Urban Planning for City Leaders. Nairobi: UN-Habitat.

UNION OF SOUTH AFRICA. 1944. Report No. 5 of the Social and Economic Planning Council on Regional and Town Planning. Pretoria: Government Printer.

UNITED NATIONS. 1976. The Vancouver Declaration on Human Settlements. United Nations Conference on Human Settlements. Vancouver, Canada.

UNITED NATIONS. 1977. Report on the United Nations Water Conference, New York: United Nations Publications.

UNITED NATIONS. 1992. The Dublin Statement on Water and Sustainable Development. Dublin, Ireland: United Nations.

UNITED NATIONS. 1997. UN Conference on Environment and Development. Retrieved from: <http://www.un.org/geninfo/bp/enviro.html> Date of Access: 10 November 2016.

UNITED NATIONS. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development A/RES/70/1. United Nations.

UNSCC (UNITED NATIONS SCIENTIFIC CONFERENCE ON THE CONSERVATION AND UTILIZATION OF RESOURCES). 1949. Proceedings of the United Nations Scientific Conference on the Conservation and Utilization of Resources 17 August - 6 September 1949. Lake Success, New York, IUCN Publication.

USGS (UNITED STATES GEOLOGICAL SURVEY). 2016. The USGS Water Science School. Retrieved from Available at: <https://water.usgs.gov/edu/gallery/global-water-volume.html> Date of Access: 07 August 2017.

UYS, M. 2008. Water Law South Africa 1912-1998. WRC Report No KV 203/08. Water Research Commission WRC Report No KV 203/08.

VAN BEEK, L.P.H., WADA, Y. & BIERKENS, M.F.P. 2011. Global monthly water stress: 1. Water balance and water availability. L.P H. van Beek. 47(7):1-25.

- VAN VUUREN, L. 2009. What's in a name: Looking back at the start of public water governance. *The Water Wheel*, 8(4):38-41.
- VAN WYK, J. 2012. *Planning Law*. 2nd ed. Cape Town: JUTA.
- VAN ZYL, J. 2014. *Introduction to Operation and Maintenance of Water Distribution Systems* (1st ed.). Republic of South Africa: Water Research Commission.
- VAN ZYL, M. 1987. States and Colonies in South Africa (1854-1902). In C. (. in Muller (Ed.), *Five Hundred Year: South African History (Afrikaans)*. Pretoria and Cape Town: Academica.
- VERBURG, P., NEUMANN, K. & NOL, L. 2011. Challenges in using land use and land cover data for global change studies. *Global Environmental Change*, 17:974-989.
- VITOUSEK, P. M. 1994. Beyond global warming: Ecology and global change. *Ecology*, 75(7), pp. 1861-1867.
- WARNER, J. 2000. *Integrated Management requires an Integrated Society: Towards a New Hydrosocial Contract for the 21st century*. AWIRU Occasional Paper No. 24. , Pretoria, South Africa: African Water Issues Research Unit, Pretoria University.
- WATERBERG DISTRICT MUNICIPALITY. 2009. *Waterberg Spatial Development Framework*. Waterberg District Municipality.
- WATERBERG DISTRICT MUNICIPALITY. 2016. *Waterberg District Biodiversity Plan*. South Africa: Waterberg District Municipality.
- WATERBERG DISTRICT MUNICIPALITY. 2017. *Waterberg District Municipality Draft IDP 2017/18*. Waterberg District Municipality.
- WATSON, I. 1993. *Hydrology: An Environmental Approach*. CRC Press.
- WEAST, R. C. 1981. *CRC Handbook of Chemistry and Physics* 61st edition. 61st edition. ed. s.l.: Chemical Rubber Co., 1981.
- WESTERN CAPE. 2005. *Provincial Urban Edge Guideline*, Cape Town: Western Cape Department of Environmental Affairs and Development Planning.

WHO/UNICEF (World Health Organization/ United Nations International Children's Emergency Fund). 2010. Joint Monitoring Programme for Water Supply and Sanitation., Geneva, Switzerland: World Health Organization and UNICEF.

WILHELMSON, R. & RAMAMURTHY, M. 2010. WW2010. A Summary of the Hydrologic Cycle. [http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/smry.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/smry.rxml)

WILSON, S., BRAY, R., & COOPER, P. 2004. Sustainable drainage systems: Hydraulic, structural and water quality advice. CIRIA C609, 6. Retrieved from <http://www.ciria.org.uk/suds/publications.htm> Date of Access: 07 August 2017.

WOLTJER, J. & ALS, N. 2007. Integrated Water Management and Spatial Planning. Journal of the American Planning Association, 2(73):211-222.

WONG, T. & BROWN, R. 2008. Transitioning to Water Sensitive Cities: Ensuring Resilience through a new Hydro-Social Contract. 11th International Conference on Urban Drainage. Edinburgh, Scotland, UK: APS Group Scotland.

WONG, T. & BROWN, R. 2009. The Water Sensitive City: Principles for Practice. Water Science & Technology, 673-682.

WOODS-BALLARD, B., KELLAGHER, R., MARTIN, P., JEFFERIES, C., BRAY, R., & SHAFFER, P. 2007. The SUDS Manual. London: CIRIA 697.

WRC (WATER RESEARCH COMMISSION). 2016. South African Mine Water Atlas. WRC Project No. K5/2234/3. Pretoria, South Africa: Water Research Commission.

WWAP (WORLD WATER ASSESSMENT PROGRAMME). 2017. United Nations World Water Assessment Programme. The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource. Paris: UNESCO.

YANG, K. 1989. Re-discussion on the Design of Chang An in West Han Dynasty. Archaeology, 4:348–356.

ZABEL, F., PUTZENLECHNER, B. & MAUSER, W. 2014. Global Agricultural Land Resources – A High-Resolution Suitability Evaluation and Its Perspectives until 2100 under Climate Change Conditions. PLOS ONE, 9(9):e107522.

ZHANG, X., & YAN, X. 2014. Spatiotemporal change in the geographical distribution of global climate types in the context of climate warming. *Climate Dynamics*, 42:595-605. doi:10.1007/s00382-013-2019-y

ZHENG, X. Y. 2015. The ancient urban water system construction of China: the lessons from history for a sustainable future. *International Journal of Global Environmental Issues*, 14(3/4):187-199

ZHOU, W., HEAD, M. & DENG, L. 2001. Climate changes in northern China since the late Pleistocene and its response to global change. *Quaternary International*, 83(5):285-292.

ZOU, C., ZHAO, Q., ZHANG, G. & ZIONG, B. 2016. Energy revolution: From a fossil energy era to a new energy era. *Natural Gas Industry*, 3:1-11.

ANNEXURE A

List of guiding thematic questions used to inform the self-evaluation assessment in Phase 2.1 of the empirical investigation.

Annexure A: Generic questions for legislation identification and assessment

Legislative hierarchy	Guiding Questions
National legislation	Identify and review national legislation relevant to municipal spatial planning, land use, water and environmental resources planning and management.
	Assess the vision statement and key principles and determine whether it holds any spatial directives and how it is applicable to the municipality.
	Identify and assess the roles and responsibilities mandated to various spheres of government or responsible authorities relating to land, water and environmental resource planning and management
	Identify any regulations published in terms of the above identified legislations which sets out norms and standards which holds development implications or opportunities.
	Identify any policies, strategies, frameworks and/or guidelines published in terms of the above identified legislations and list them for further discussion.
Provincial legislation	Identify and review provincial legislation relevant to municipal spatial planning, land use, water and environmental resources planning and management.
	Assess the vision statement and key principles and determine whether it holds any spatial directives and how it is applicable to the municipality.
	Identify and assess the roles and responsibilities assigned to different authorities in land, water and environmental resource planning and management.
	Identify any regulations published in terms of the above identified provincial legislations setting norms and standards for development and may hold development implications or opportunities.
	Identify any policies, strategies, frameworks and/or guidelines published in terms of the above identified provincial legislations and list them for further discussion.
Review Municipal By-laws	Identify and review all municipal by-laws relevant to municipal spatial planning, land use, water and environmental resources planning and management.
	Assess the vision statement and key principles of the by-law and determine whether it holds any spatial directives.
	Identify and assess the roles and responsibilities assigned to different authorities in land, water and environmental resource planning and management by the by-law.
	Identify any regulations published in terms of the above identified municipal by-laws setting norms and standards for development and which may hold development implications or opportunities.

	Identify any policies, strategies, frameworks and/or guidelines published in terms of the above identified by-laws and list them for further discussion.

Source: Own Construction (2018)

ANNEXURE B

List of legislations and the policies and plans to be prepared by various spheres of government, sector departments and institutions which holds land, water and environmental resource planning and management implications.

Annexure B: Mandatory policies and plans

National Legislation	Policies and plans to be prepared as by government sectors as per their legislative mandate					
Legislation title	National	Catchment	Provincial	Regional / District	Municipal	Site Specific
Spatial Planning and Land Use Management Act (Act no. 16 of 2013)	National Spatial Development Framework (Section 13)		Provincial Spatial Development Framework (Section 15)	Regional Spatial Development Framework (Section 18)	Municipal Spatial Development Framework (Section 20)	
					Municipal Land Use Scheme (Section 23)	
National Water Act (Act no. 36 of 1998)	National Water Resource Strategy (Section 5)	Catchment Management Strategy (Section 8)				
	National Groundwater Strategy (Should form part of NWRS)					
Water Services Act (Act no. 108 of 1997)					Water Services Development Plan (WSA) (Section 12)	
National Environmental Management Act (Act no. 107 of 1998)	National Environment Outlook Report (Section 16)		Environmental Implementation Plans (Section 16)	Environmental Management Framework (Section 24(2) and EIA Regulations Chp 8, part1)	Environmental Management Framework (Section 24(3) and EIA Regulations Chp 8, part1)	
	National Environmental Management Framework (Section 24(2))		Provincial Environment Outlook Report (Section 16)			
	Environmental Management Plans (Section 11 (1))					

National Legislation	Policies and plans to be prepared as by government sectors as per their legislative mandate					
Legislation title	National	Catchment	Provincial	Regional / District	Municipal	Site Specific
	Environmental Implementation Plans (Section 11 (2))					
National Environmental Management: Biodiversity Act (Act no. 10 of 2004)	National Biodiversity Framework (NBF) (Section 39)		Provincial Spatial Biodiversity Plan (As per NBF (Priority action 16))	Bioregions and bioregional plans (As per NBF Priority action 17))		
	National Biodiversity Assessment (As per NBF)		Provincial conservation plans (As per NBF)			
	National Biodiversity Strategy and Action Plan (As per NBF)					
National Environmental Management: Air Quality Act (Act. No. 39 of 2004)	National Framework for Air Quality Management (Section 7)		Provincial Air Quality Management Plan (Section 15(1) as a component of EIP / EMP)		Municipal Air Quality Management Plan (Section 15 as a component of the IDP) / Model Air Pollution Control By-law	
	National Air Quality Management Plan (Section 15(1) as a component of EIP / EMP)					
National Environmental Waste Act (Act no. 59 of 2008)	National Waste Management Strategy (Section 6)		Provincial Integrated Waste Management Plan (Section 11(1))		Municipal Integrated Waste Management Plan (Section 4(a) as a component of the IDP)	
National Environmental Management: Integrated Coastal Management Act (Act no. 24 of 2008)	National Estuarine Management Protocol (Section 33)		Provincial Coastal Management Programme (Section 46)	District Estuarine Management Plan (Section 33(3))	Municipal Coastal Management Plan (Section 48)	Coastal Zones planning schemes (Section 56)

National Legislation	Policies and plans to be prepared as by government sectors as per their legislative mandate					
Legislation title	National	Catchment	Provincial	Regional / District	Municipal	Site Specific
	National Coastal Management Programme (Section 44)		Provincial Estuarine Management Plan (Section 33(3))		Municipal Estuarine Management Plan (Section 33(3))	Declaration of special management areas (Section 23)
Disaster Management Act (Act no. 57 of 2002)	National Disaster Management Framework (NDMF) (Section 6)		Provincial Disaster Management Plan (Section 28(3)(b))	Disaster Management Plan (Section 52)		
	National Disaster Management Plan (As per NDMF)					
National Land Transportation Act (Act no. 5 of 2009)	National Land Transport Strategic Framework (Section 34)		Provincial Land Transportation Framework (Section 35)	District Integrated Transportation Plan (Section 36)	Municipal Integrated Transportation Plan (Section 36)	
Municipal Systems Act (Act no. 32 of 2000)				District Integrated Development Plan (Section 27)	Municipal Integrated Development Plan (Section 25)	
				Local Economic Development Strategy (Section 25)	Local Economic Development Plan (Section 26)	
Municipal Finance Management Act (56 of 2003)					Service Delivery and Budget Implementation Plan (Section 53(1))	
					Medium Term Revenue and Expenditure Framework (Section 16(2))	
National Housing Act (Act 107 of 1997)	National Housing Code (Section 4(1))		Provincial Housing Policy and multi-year		Municipal Housing Sector Plan (Section 9)	

National Legislation	Policies and plans to be prepared as by government sectors as per their legislative mandate					
Legislation title	National	Catchment	Provincial	Regional / District	Municipal	Site Specific
	Comprehensive Housing Plan (Section 4 (c))		Housing Sector Plan (Section 7(2)(g))			
National Environmental Management: Protected Areas Act (Act no. 57 of 2003)						Protected Areas Management Plan (Section 39)

Source: Own Construction (2018)

ANNEXURE C

List of guiding thematic questions used to inform the self-evaluation assessment in Phase 2.1 of the empirical investigation.

Annexure C: Policy analysis: generic questions

Hierarchy	Guiding Questions
National policies	Identify and review national policies relevant to municipal spatial planning, land use, water and environmental resources planning and management.
	Assess the vision statement and key development principles and determine whether it holds any spatial directives and how is it applicable to the municipality.
	Assess the aims, objective and targets (if any) relating to land, water and environmental resource planning and management.
Provincial policies	Identify and review provincial policies relevant to municipal spatial planning and land use management as well as water and environmental resources planning and management.
	Assess the vision statement and key development principles and determine whether it holds any spatial directives and how is it applicable to the municipality.
	Assess the aims, objective and targets (if any) relating to land, water and environmental resource planning and management.
Municipal policies	Identify and review municipal policies relevant to municipal spatial planning and land use management as well as water and environmental resources planning and management.
	Assess the vision statement and key development principles and determine whether or not it holds any spatial directives and how is it applicable to the municipality.
	Assess the aims, objective and targets (if any) relating to land, water and environmental resource planning and management.
National Sector Plans	Identify and review all strategic sector plans (water, environmental, economic, transportation, energy etc) adopted by the national departments and determine to what extent will the plans affect the municipality.
	Assess the vision, mission, objective and desired outcome of the plans.
	Identify and review development principles and highlight any spatial directives.
	Identify all projects which might have a physical, environmental and socio-economic impact on the municipality. This may include the physical development of new infrastructure, the expansion of protected areas, and other mega project deemed to create socio-economic growth in investment opportunity.
	Identify all budgets allocated to the implementation of the plan and identify the potential beneficiaries (communities)

Provincial Sector Plans	Identify and review all strategic sector plans (water, environmental, economic, transportation, energy etc) adopted by province government departments and determine to what extent will the plans affect the municipality.
	Asses the vision, mission, objective and desired outcome of the plans.
	Identify and review development principles and highlight any spatial directives.
	Identify all projects which might have a physical, environmental and socio-economic impact on the municipality. This may include the physical development of new infrastructure, the expansion of protected areas, and other mega project deemed to create socio-economic growth in investment opportunity.
	Identify all budgets allocated to the implementation of the plan and identify the potential beneficiaries (communities)
Regional or Catchment Plans	Identify and review all regional or catchment plans adopted by the relevant authority affecting the municipality.
	Asses the vision, mission, objective and desired outcome of the plans.
	Identify all projects which may have a physical, environmental or socio-economic impact on the municipality and identify the allocated budget.
	Identify existing development constraints (overutilization of resources; resource pollution; infrastructure integrity) and future development opportunities (groundwater potential).
	Identify which areas are prioritised for development (areas of future growth)
	Determine the existing levels of service targets
District or Municipal sector plans	Evaluate the existing water tariff structure
	Identify and review all strategic sector plans (water, environmental, economic, transportation, energy etc) adopted by the district of municipal council and determine to what extent will the plans affect the municipality.
	Asses the vision, mission, objective and desired outcome of the plans.
	Identify and review development principles and highlight any spatial directives.
	Identify all projects which might have a physical, environmental and socio-economic impact on the municipality. This may include the physical development of new infrastructure, the expansion of protected areas, and other mega project deemed to create socio-economic growth in investment opportunity.
	Identify all budgets allocated to the implementation of the plan and identify the potential beneficiaries (communities)
	Asses the legal definitions of existing zonings

Source: Own Construction (2018)

ANNEXURE D

List of guiding thematic questions used to inform the self-evaluation assessment in Phase 2.1 of the empirical investigation.

Annexure D: Water Sensitive Policy Analysis: Detailed questionnaire

Documents and information required	Questions to be answered
National Development Plan: Vision 2030	What is the overall strategic objective NDP applicable to spatial planning, water and environmental resources? does it have any implication for the study area?
	How does the strategic objectives of the NDP relate to the study area?
	Are there any development targets which land or water resources will have related implications?
	Are there any development targets which land or water resources will have related implications?
National Infrastructure Plan and its Strategic Integrated Projects (SIP)	Are there any specific goals and do they impose spatial implications?
	Are there any SIP's that will have an environmental, economic or social impact on the municipality?
Medium Term Strategic Framework (2015-2019)	Are there any strategies and action plans to be addressed in the SDF?
The Integrated Urban Development Framework (2016-2019)	What is the IUDF Vision and how can it inform the municipal SDF?
	What are the development principles and how should the municipality address them spatially?
Cities Support Program	Are there any Cities Support Programs currently implemented or planned for within the municipality?
Agri-park Initiative	Are there any strategic plans in place to address agricultural development within the municipality?
	Are there proposed Agri-parks in the study areas?
	Identify the Farmer Production Support Units
	Identify the Rural-Urban Market Centre (RUMC)
	Identify the Agri-hub (AH)
Comprehensive Rural Development Plan (2009)	Are there any specific goals and do they impose spatial implications?
	Does the plan have any water resource related implication such as target for services delivery?

Agricultural Policy Action Plan (APAP)	How does localisation of agricultural practices apply to the municipality?
Land claims and status	Are there any land claims with accompanying spatial data which affects the municipality?
Agricultural datasets	Which agricultural datasets are available for public use?
	Which datasets should be incorporated into the SDF analysis?
	What is the water demand for agricultural practice in the municipality?
	Do the agricultural practices within the municipality impose water quality implications?
National Water Resources Strategy (NWRS 2013)	What is the vision, mission and aims of the NWRS?
	Which resource management initiatives related to the municipality?
	Are there any National projects to be implemented within the municipality?
	Are there any water sensitive planning approaches which can be implemented within the municipality?
Water-related datasets and research finding which should be used to inform the SDF.	Which water-related datasets are available for public use?
	Which datasets should be incorporated into the SDF analysis?
	Any studies or research papers which can be used to inform the SDF analysis or proposals.
National Biodiversity Assessment	Which maps and spatial datasets area applicable to the municipality – downloadable from the BGIS
	Are there any CBA's and ESA's found within the study area?
National Biodiversity Strategy and Action Plan (NBSAP)	Which strategies and actions can be implemented through spatial planning and vice versa?
National Protected Areas Expansion strategy	Does the strategy identify areas eligible for expansion of protected areas within the municipality?
	What is the recommendation for expanding protected areas which should form part of the SDF?
	Are there any areas currently under a biodiversity stewardship contractual agreement?
List of ecosystems that are threatened and in need of protection.	Are there any ecosystems gazetted as critically endangered (CR), Endangered (EN), and vulnerable (VU)
Integrated Waste Management Plan	What are the National Norms and Standards for waste management?
	Does the strategy have any management guidelines for the prevention of groundwater contamination?
	Does the strategy have any management guidelines for land rehabilitation?

	Does the national contaminated land register indicate areas of concern within the municipality?
	Does the national waste information system provide spatial data applicable to the municipality?
	Are there any licenses for hazardous waste within the municipality?
NATMAP 2050	What is the Transport Vision as per NATMAP 2050?
	Is there any transport infrastructure of national significance located within the study area?
	Does the integrated transport development plan for the short-, medium- and long-term up to 2050 have any impact of the study areas?
	Is there any spatial data available for public use?
National Land Transport Strategic Framework	What are the proposed NLTSF strategies?
	Does the NLTSE hold any implication for land and water resources development and planning?
2009: The Revised Housing Code	Are there any Financial Programmes, Social and Rental Housing Programmes, Incremental Housing Programmes and Rural Housing Programmes currently implemented in the municipality?
	Are there any upgrading of Informal Settlements Programme, the Social/Rental Housing Programme and Integrated Residential Development Programme currently underway or planned for within the municipality?
	Does the municipality apply the national norms and standards for the construction of stand-alone residential dwellings?
Provincial Growth and Development Strategy	Is there alignment between the Provincial Growth and Development Strategy and the NDP?
	Which spatial implication can be gathered from the strategy?
	Are there any norms and standards for infrastructure services delivery?
Provincial and/or District IDP	What is the provincial vision statement?
	What is the Districts vision statement?
	What challenges and opportunities exist within the municipality?
	List of the location and budgets allocated for capital investment projects from sector departments (Energy, water & sanitation, waste...)
Provincial and/or District SDF	Does the provincial SDF have an established spatial hierarchy?
	Does the provincial and district spatial hierarchy align?
	Is the study areas subject to any provincial or district nodes, growth point and investment corridors?

	Are there any spatial challenges or opportunities which should be addressed on local level?
District Rural Development Plan (Agri-park)	What is the existing state land with agricultural potential in the municipality?
	Are there any identified Farmer Production Support Units, Rural-Urban Market Centre (RUMC) and/or an Agri-hub (AH) planned within the municipality?
	Which agricultural value change has been identified to the area?
	Which communities will be most impacted by the Agri-park initiative?
	Is the data available in GIS format?
Land claims and status	Are there any traditional authorities within the District which will impact the municipality?
	Is the data available in GIS format?
	Are there any land claims with accompany spatial data which affects the municipality?
Provincial / District Water Sector Plan or master plan	Are there any priority areas identified for services delivery?
	Are there any major water and sanitation projects underway?
Catchment Management Strategy	Which strategies, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of water resources within its WMA have been set by the CMA?
	Do the water allocation plans within the strategy have any implication for the municipally?
	What are the expectations of existing and potential water users?
Water Reconciliation Strategy	What are the current available water resources yield within the Catchment?
	Are there any targets?
	Which drivers of growth have been identified?
	By which date a high-growth requirement exceed current resources?
	What will be the additional amount of water required before a certain date?
	Are there any measures to supply additional water?
Provincial Biodiversity Management Plan	Are there any Critical Biodiversity areas (CBA's) or environmentally sensitive areas (ESA's) within the study area?
	Which management guidelines are applicable to the SDF?
Provincial list of threatened ecosystems and species	Is there a provincial list of threatened ecosystems and species applicable to the study area?

Integrated Waste Management Plan (IWMP)	Are there any areas within the municipality negatively impacted by poor waste management practices which affects the health and the environment (specifically with regards to groundwater);
	Are there any new facilities for disposal and decommissioning of existing waste disposal facilities identified within the municipality?
Provincial Land Transportation Framework (PLTF) / District Integrated Transport Plan (DITP)	What is the Vision of the PLTF?
	What spatial implications (structuring or non-structuring) does the PLTF have on the municipality?
Provincial Housing Sector Plans	Are there any areas within the municipality identified for housing delivery?
	Are there any housing standards or preferred housing typologies applicable to the local municipality?
The location and extent of existing and future mining operations.	Which areas are currently used for mining?
	Which areas will be required in future?
Municipal Growth and Development Plan (GDP)	Is there alignment between the NDP, the Provincial GDP, District GDP and the Municipal GDP?
	Which spatial implication can be gathered from the strategy?
Municipal IDP	What are the Districts and municipalities vision statement?
	What challenges and opportunities exist within the district and the municipality?
	Which sector plans, impacting on both land and water resources are available?
	List of the location and budgets allocated for capital investment projects from sector departments (Energy, water & sanitation, waste...)
Existing Municipal SDF (if any)	What is the spatial vision and mission statement?
	Does the SDF have any Spatial Development Principles in place?
	Does the SDF's present a spatial hierarchy and how does it align with the provincial spatial hierarchy?
	Are there any identified district and municipal nodes, growth point and investment corridors?
	Are there any environmentally sensitive areas to be protected?
	Defined urban areas and settlements;
	Are there any urban edges or urban growth boundary delineation application to the municipality?
	Is there any development project underway which will have a significant spatial restructuring impact on the municipality?
	Is the data available in GIS format?

Municipal Valuation Roll	Different forms of land tenure and their spatial distribution;
	Land ownership;
	The value of land.
Municipal Land Use Scheme	Data on the following should be collected:
	· Existing Zoning
	· Existing land use
	· Existing vacant land
	· Land ownership
	· Illegal land uses
	· Amendments to existing scheme
Municipal Local Economic Development Plan	Are there any strategic investment areas, areas where economic growth should be encouraged or discouraged?
	Are there any spatial implications of LED strategies?
Land claims and status	Are there any land claims with accompany spatial data which affects the municipality?
	Are there any traditional authorities within the District which will impact the municipality?
	Is the data available in GIS format?
Agriculture (Rural Development plan)	Which areas will be used for agriculture in future?
	The location of valuable agricultural land that should be protected?
Water Services Development Plan (Chapter 3 of the Water Services Act no 108 of 1997)	Existing levels of services; services backlog; current demand and capacity levels as well as costs and thresholds for the expansion of these;
	Development opportunities and constraints;
	List of the location and budgets allocated for capital investment projects from sector departments (Energy, water & sanitation, waste...)
	Water tariff structure
	Water conservation and demand management strategies
Municipal Asset Management Plan	The location, extent and condition of water and sanitation networks?

Environmental Management Plan	Spatial information on the municipality's geology, soil, topography and slope analysis.
	Areas of agricultural potential
	Links between core areas/partially functional ecosystems
	Register of Protected Areas, Provincial Protected Areas, Nature Reserves, World Heritage Sites, Protected Forest Areas, Mountain Catchment Areas
Municipal Integrated Transport Plan (DITP)	Does the CIP have a rationalisation plan in place?
	Does the CIP include a public transport plan and where will this take place?
	Will the CIP have a spatial impact the layout and density of settlements within the municipality?
	Planned investments for corridors, nodes, modal transfer points, non-motorized transport, ingress and egress requirements, car-free areas, parking standards.
	Roads to be upgraded
Stormwater Management Plan	Are there any stormwater quality conditions?
	Post development standards in place?
	Strategies to reduce and treat stormwater?
Municipal Housing Sector Plan	Which settlements within the municipality has been identified for housing upgrade projects?
	Does the municipality have a preferred housing typology or standards for housing delivery in place?

Source: Own Construction (2018)

ANNEXURE E

Annexure E: List of spatial dataset and sources, list all existing spatial datasets to be used in conducting a water sensitive spatial analysis. The table also provides a code, a description of the type of spatial dataset, the source (URL – If available online) and the specific government department or national institution where the data can be obtained from.

Annexure E: List of spatial dataset and sources

Shapefile Name	Code	Polygon / line / point	URL	WRC	ARC	Municipal Demarcation board	SANBI	Chief Surveyor General	Local government	DWS	PlanetGIS	DEA		DBE (Education)	mapIT	DMR	ESRI
Basemap and data																	
Provincial Boundaries	A01	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm			x		(x)	x		x						x
District Boundaries	A02	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm			x		(x)	x		x						x
Local Municipal Boundaries	A03	Polygon	http://www.demarcation.org.za/site/2017-2018-technical-municipal-boundary-alignment/#			x		(x)	x		x						x
Towns point data	A04	Point	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						x
Ward Boundaries	A05	Polygon	http://www.demarcation.org.za/site/2016-3/ , http://csg.dla.gov.za/spatial.htm			x		(x)	x		x		x				
Main Place Boundary	A06	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm			x		(x)	x		x		x				

Subplace boundary	A07	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm			x		(x)	x		x		x				
General Plans Boundaries	A08	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						
Allotment or Township Boundaries	A09	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						
Water Management Boundaries	A10	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x						x							x
Primary Catchment Boundaries	A11	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x						x							x
Secondary Catchment Boundaries	A12	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x						x							x
Tertiary Catchment Boundaries	A13	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x						x							x
Quaternary Catchment Boundaries	A14	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x						x							x
Cadastral data																	
Farm Portions Cad	A15	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						x
Parent Farms	A16	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						x
Holdings Cad	A17	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						x
Erf Cadastre	A18	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						x

Public Places CAD	A19	Polygon	https://planetgis.co.za/browse.php?id=11 , http://csg.dla.gov.za/spatial.htm					(x)	x		x						x
Infrastructure Data																	
Road Networks	A20	Line	https://mapit.co.za/ , http://csg.dla.gov.za/spatial.htm					(x)	x						(x)		x
Water treatment works	A21	Point		x					x	x							
Wastewater treatment works	A22	Point		x					x	x							
Water reticulation network	A23	Line		x					x	x							
Wastewater reticulation network	A24	Line		x					x	x							
Boreholes	A25	Point	http://www.dwa.gov.za/iwqs/gis_data/	x					x	x							
Pump stations	A26	Point	http://www.dwa.gov.za/iwqs/gis_data/	x					x	x							
Inlet and output points	A27	Point	http://www.dwa.gov.za/iwqs/gis_data/	x					x	x							
Electricity Infrastructure Network	A28	Line							x	x							
Natural environment																	
Topography (slope)	A29	Raster	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx		(x)		x										
Contours	A30	Line	https://planetgis.co.za/browse.php?id=11								x						
Primary river network	A31	Line	http://bgis.sanbi.org/Search?SearchTerm=rivers	x	x		x			x							

Secondary River Network	A32	Line	http://bgis.sanbi.org/Search?SearchTerm=rivers	x			x			x							
Wetlands and estuaries	A33	Polygon	http://bgis.sanbi.org/Search?SearchTerm=wetlands	x			x			x							x
Impoundments	A34	Polygon	http://bgis.sanbi.org/Search?SearchTerm=inland+water	x			x			x							x
Land Cover data	A35	Raster	http://bgis.sanbi.org/SpatialDataset		(x)		x		x		x	x					
Gullies	A36	Polygon			(x)		x			x							
Mean annual Temperature	A37	Raster	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx		(x)		x			x							
Mean Annual Precipitation	A38	Raster	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx		(x)		x			x							
Mean Annual Evaporation Rate	A39	Polygon	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx		(x)		x			x							
Mean Annual Runoff	A40	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
Utilisable Groundwater Exploration Potential	A41	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
High Groundwater Recharge Potential	A42	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
Groundwater quality	A43	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
Boreholes with Nitrate (n)	A44	Point	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							

Boreholes with Fluoride (f)	A45	Point	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
Boreholes with Iron (Fe)	A46	Point	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
Underlining structuring elements																	
Geology	A47	Polygon	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx	x	(x)		x										
Swelling clay	A48	Polygon	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx	x	(x)		x										
Soil drainage	A49	Polygon	http://www.arc.agric.za/arc-iscw/Pages/Earth-Observation.aspx	x	(x)		x			x							
Depth to groundwater	A50	Polygon	http://waterresourceswr2012.co.za/resource-centre/	x			x			x							
Protected & Management areas																	
Formal protected areas	A51	Polygon	https://egis.environment.gov.za/data_egis/user	x			x		x			x					
Critical Biodiversity Areas (CBA)	A52	Polygon	http://bgis.sanbi.org/SpatialDataset				x		x								
Ecological Support Areas (ESA)	A53	Polygon	http://bgis.sanbi.org/SpatialDataset				x		x								
river FEPA's	A54	Line	http://bgis.sanbi.org/SpatialDataset	x			x			x							
wetlands FEPA'S	A55	Polygon	http://bgis.sanbi.org/SpatialDataset	x			x			x							
Wetlands Cluster	A56	Polygon		x			x			x							
Fish sanctuaries	A57	Polygon		x			x			x							

and associated sub-quaternary catchments																	
Upstream Management Areas	A58			x			x			x							
Phase 2 FEPA's	A59	Line		x			x			x							
free flowing rivers	A60	Line		x			x			x							
High Agricultural potential land	A61	Polygon					x			x							
Mining	A62	Raster										x				(x)	
Sediment yield 1 000 t/a	A63																
Total Dissolvent Solids (TDS)	A64																
Cumulative Neutralised Streamflow	A65																

(x) means the data is not free.

Source: Own Construction (2018)

ANNEXURE F

Weather SA rainfall data.

Annexure F: Lephalale LM daily rainfall 2017-2018

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	1,2	0	4,4
6	1,6	0	0	1,8	0	0	0	0	0	11,4	0	18,8
7	27,6	0	8	1,4	0	0	7	0	0	1,4	0	0
8	7,2	0	0	0	0	0	0	0	0	0,8	0	0
9	0	6,2	0	0	0	0	0	0	0	0	1,8	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0,8	0,2
12	0	0,8	0	0	0	0	0	0	0	0	0	3,6
13	0	0	0	0	1,6	0	0	0	0	0	0	0
14	0	0	0	38	0	0	0	0	0	0	0	0
15	7,2	0	0	0,4	0	0	0	0	0	0	4,8	0
16	19,2	0	0,2	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0,6	0	0	0	0	0	0	0	0	0	0
19	0	41,8	0	0	0	0	0	0	0	0	0	0
20	0	17,8	0	0	0	0	0	0	0	0	0	0
21	0	13,2	0	0	0	0	0	0	0	0	0	0
22	0	4,4	0	0	0	0	0	0	0	0	0	1
23	0	0,4	0	3,8	0	0	0	0	0	0	0	2,2
24	6,2	0,6	0	0	0	0	0	0	0	0	0,4	0
25	0	0	0	0	0	0	0	0	0	0	10	0
26	3,6	9,4	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	3	0	0	0	0	0	0	0	0	0	0	0
29	13,8	0	0	0	0	0	0	0	0	0	0	0,2
30	26	0	0	0	0	0	0	0	0	0	0	0
Total Monthly	115,4	95,2	8,2	45,4	1,6	0	7	0	0	14,8	17,8	30,4

Source: SA Weather services - Lephalale 2017 (Daily Rain (mm) Data for station [0674341 8] (Extracted 2018/01/23 15:18)

Annexure F: Mogalakwena LM daily rainfall 2017-2018

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1										0,2		
2										6		
3												
4												
5												4,4
6				3						20,8		46,2
7	37			0,2						5		0,2
8	11		***	2						11		
9			***							2		
10			***									14,2
11												1,8
12					20,2							8,2
13			***	2	17,2						24,4	0,2
14		3,6	***	38,8	0,2						0,2	0,2
15				8,6							6,6	
16		0,6		0,2								
17		2,2										
18												
19										0,2		
20		1,2										
21		8,8										
22		12,2										0,2
23		0,2		1,8								1,8
24		1	5	0,2							2	0,2
25			7								53	
26		5	0,2								0,2	
27										19,8		
28										0,2		
29		***										18,4
30		***							1,4			0,2
31		***		***		***			***		***	
Total Monthly												

Source: SA Weather services – Mokopane 2017 (Daily Rain (mm) Data for station [0633882 7] (Extracted 2018/01/23 15:18)

ANNEXURE G

Land use water quality threat rating adopted from Macfarlane *et al.* (2014).

Annexure G: Land use water quality threat rating

Sector	Land use / activity	Land audit classification	Sedimentation and turbidity	Increased inputs of nutrients	Increased organic contaminants	Concentration of salts (salinization)	Pathogens
Agriculture	Agriculture (worst case)	Agriculture	0,2	1	0,8	0,8	1
Industry	Ceramic works	Brick Yard	0,6	0,2	0,2	0,6	0,2
	Industry (worst case)	Industrial 1,2,3 (Zoning information)	1	0,8	1	0,8	0,8
Mixed-use/ Commercial/ Retail/ Business	Core Mixed-use	Special	0,4	0,4	0,6	0,4	0,4
	Petrol station / Fuel depot	Filling Station	0,4	0,2	0,6	0,2	0,2
	Offices	Offices	0,4	0,2	0,2	0,2	0,4
	Mixed-use/Commercial/Retail/Business (worst case)	Business 1,2,3 (Zoning information)	0,4	0,4	0,6	0,4	0,4
Civic and Social	Government and municipal	Municipal and Government	0,4	0,2	0,2	0,2	0,4
	Place of worship	Place of Worship	0,2	0,2	0,2	0,2	0,4
	Education	Educational; School and Private School	0,2	0,2	0,2	0,2	0,4
	Cemetery	Cemetery	0,4	0,4	0,2	0,2	0,4

Residential	Health and Welfare	Clinic; Hospitals and Health Care Facilities	0,4	0,2	0,6	0,2	0,4
	Civic and Social (worst case)	Institutional	0,4	0,4	0,6	0,2	0,4
	Residential Low impact / Residential only	Residential 1 (Zoning information)	0,2	0,2	0,2	0,2	0,4
	Residential Medium Impact	Residential 2 (Zoning information)	0,4	0,4	0,4	0,2	0,4
	High density urban - Residential High Impact	Residential 3 (Zoning information)	0,6	0,6	0,6	0,2	0,6
	Hotel (Hotel) (Guest house)	Hotel; Guest house and Lodge (Zoning information)	0,4	0,6	0,4	0,2	0,4
Open space	Informal settlements	Residential Informal (Zoning information)	0,8	0,8	0,4	0,2	1
	Sports fields	Sports Fields	0,2	0,4	0,6	0,2	0,2
	Maintained lawns and gardens	Private Open Space	0,2	0,4	0,4	0,2	0,2
Transportation infrastructure	Open space (worst case)	Public Open Space ; Vacant land and Undetermined	0,2	0,6	0,6	0,4	0,2
	Transportation infrastructure (worst case)	Transport; Roads and Parking	0,8	0,6	0,4	0,4	0
Service infrastructure	Service infrastructure (worst case)	Public Services Infrastructure and Utilities	0,8	1	1	0,8	1

Source: Own Construction adopted by Macfarlane *et al.* (2014)

ANNEXURE H

Turn-it-in Report

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ORIGINALITY REPORT

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