REVIEW AND GAP ANALYSIS OF WATER SENSITIVE URBAN DESIGN (WSUD) IN WINDHOEK, NAMIBIA

by

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Declaration

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Abstract

With an ever-increasing population and global warming, fresh water resources are nearing depletion resulting in a global water crisis. As a consequence, cases of drought have been reported worldwide especially in sub-Saharan Africa. In addition to climate change, urbanisation adds strain to infrastructure as well as water supply and the management of water resources. As a result, most developing countries are faced with a water management challenge. There is thus a need for a paradigm shift towards an Integrated Water Management (IWM) approach. Worldwide, countries have responded to the Integrated Urban Water Management (IUWM) concept through the implementation of various management strategies; with Water Sensitive Urban Design (WSUD) emerging from Australia. Some closely allied management strategies in response to IUWM emerged in the USA as Low-Impact Development (LID), in the UK as Sustainable Drainage Systems (SuDS), and in New Zealand as Low-Impact Urban Design and Development (LIUDD).

Namibia is situated along the south-west coast of Africa and is considered the driest country in sub-Saharan Africa. It is characterised by a semi-arid environment, with more than 80% covered by desert or semi-desert. The country is regularly afflicted by drought and has fluctuating and unreliable rainfall patterns, often accompanied by high evaporation rates.

The City of Windhoek, as the capital city, the biggest municipality and also the largest densely populated town in Namibia, is faced with an ever-increasing shortage of water for its inhabitants. For close to 50 years, the water scarcity situation has led to direct waste water reclamation for potable re-use in Windhoek. Other measures implemented by the City of Windhoek (CoW) towards IUWM include Water Demand Management (WDM), Managed Aquifer Recharge (MAR) and Water Conservation (WC). In order for Windhoek to transform into a Water Sensitive City, the implementation of WSUD is imperative. Although the CoW has implemented measures towards IUWM, more options still need to be explored in order to contribute to IUWM processes and to ultimately become a Water Sensitive City.

This research was aimed at conducting a comprehensive review of existing WSUD practices within the CoW and identifying gaps pertaining to WSUD implementation. The research confirmed, via a review of relevant literature, that the implementation of WSUD mainly flourishes when documented policies and regulations drive implementation. To review WSUD implementation in the CoW, this study followed a qualitative research approach by gathering data via online questionnaires using the SurveyMonkey platform. To validate the survey outcomes, structured interviews were conducted with selected survey participants to gain more insight into the outcomes. For the data collection, the study targeted a sample of managers and specialists from the three departments within the CoW that deal with urban infrastructure design and planning. A 72% response rate was achieved.

The study revealed that there was a general understanding and knowledge of WSUD concepts among all the CoW stakeholders involved in water management, planning and design. This was mostly due to their academic knowledge and sometimes via exposure to existing WSUD practices within the city. Water Demand Management, Water Recycling, and Voluntary Green Roofs and Rainwater Harvesting were identified as existing WSUD options currently practised within the CoW. The study identified lack of capacity, lack of knowledge, lack of management

support, a fragmented approach, the absence of policies and legislation, and no perceived financial benefits as barriers to WSUD implementation within the CoW.

Based on the above findings, the study recommended that the City of Windhoek address existing barriers to WSUD implementation, increase awareness of WSUD within the city, secure government funding and apply for carbon credits to upscale the implementation of WSUD.

Key words:

Integrated Urban Water Management, Sustainable Drainage Systems, Water Conservation, Water Demand Management, Water Sensitive Urban Design

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List of Acronyms

CAN	Central Area of Namibia
CoW	City of Windhoek
EGS	Ecosystem Goods and Services
ESD	Ecologically Sustainable Development
GWRP	Goreangab Water Reclamation Plant
IWRM	Integrated Water Resources Management
IUWM	Integrated Urban Water Management
IWM	Integrated Water Management
LID	Low-Impact Development
LIUDD	Low-Impact Urban Design and Development
MAR	Managed Aquifer Recharge
MAR&R	Managed Aquifer Recharge and Recovery
MDG	Millennium Developmental Goals
NDP	National Development Plan
NDPI	First National Developmental Plan of Namibia
NDPII	Second National Developmental Plan of Namibia
NGWRP	New Goreangab Water Reclamation Plant
OGWRP	Old Goreangab Water Reclamation Plant
PRS	Poverty Reduction Strategy
SABS	South African Bureau of Standards
SDG	Sustainable Development Goal
SuDS	Sustainable Drainage Systems
SWH	Stormwater harvesting
UNICEF	United Nations Children's Fund
WASP	Water Supply and Sanitation Policy
WC	Water Conservation
WDM	Water Demand Management
WHO	World Health Organization
WRMA	Water Resources Management Act
WSC	Water Sensitive City
WSS	Water Sensitive Settlement
WSUD	Water Sensitive Urban Design

1. INTRODUCTION

1.1 Background to the problem

With an ever-increasing population and global warming, fresh water resources are nearing depletion resulting in a global water crisis. As a consequence, cases of drought have been reported worldwide especially in sub-Saharan Africa. In addition to climate change, urbanisation adds strain to infrastructure as well as water supply and the management of water resources. Most developing countries are facing water management challenges and a potential water crisis. Urbanisation contributes significantly to this water management challenge, with water demand increasing with population growth, and with water quality deteriorating due to a lack of effective stormwater management. Effective water management has become a challenge for most African cities, and also across the world.

Research shows that 50% of the world is urbanised (Swilling, Pieterse & Hajer, 2016). This means that most of the world's population live in towns or cities. According to the United Nations Department of Economic and Social Affairs (UN DESA), the urban population will double by 2050, compared to that of 2010 (Pieterse & Parnell, 2014).

Due to high urbanisation rates, cities are faced with the challenge of meeting the ever-increasing demand for water supply as well as providing safe and clean water to their citizens. According to the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) (Jacobsen, Webster & Vairavamoorthy, 2013), in 2010 only 62% of Africans had access to safe drinking water and about 31% had access to adequate sanitation in rural areas. On the other hand, 83% of Africans living in urban areas had access to safe drinking water and 43% had access to adequate sanitation. Clearly, despite efforts to provide improved urban water supply to 84 million Africans and improved sanitation to 42 million Africans between the year 2000 and 2010, access to water remains a challenge (Jacobsen *et al.*, 2013). Hence, there is a need for a paradigm shift towards the holistic and integrated management of urban water.

1.2 The water situation in Namibia

Namibia is situated along the south-west coast of Africa and is considered the driest country in sub-Saharan Africa. It is characterised by a semi-arid environment, with more than 80% covered by desert or semi-desert. The country is regularly afflicted by drought and has fluctuating and unreliable rainfall patterns, often accompanied by high evaporation rates. The average annual rainfall is 360mm, of which 83% is lost through evaporation, 14% is utilised by vegetation, 1% goes to aquifer recharge and the remaining 2% (7.2mm) results in surface runoff (Crovello, Davidson & Keller, 2010). Due to the arid nature of the area, the evaporation rate often exceeds the rainfall, which can lead to a depletion of groundwater (Crovello *et al*., 2010).

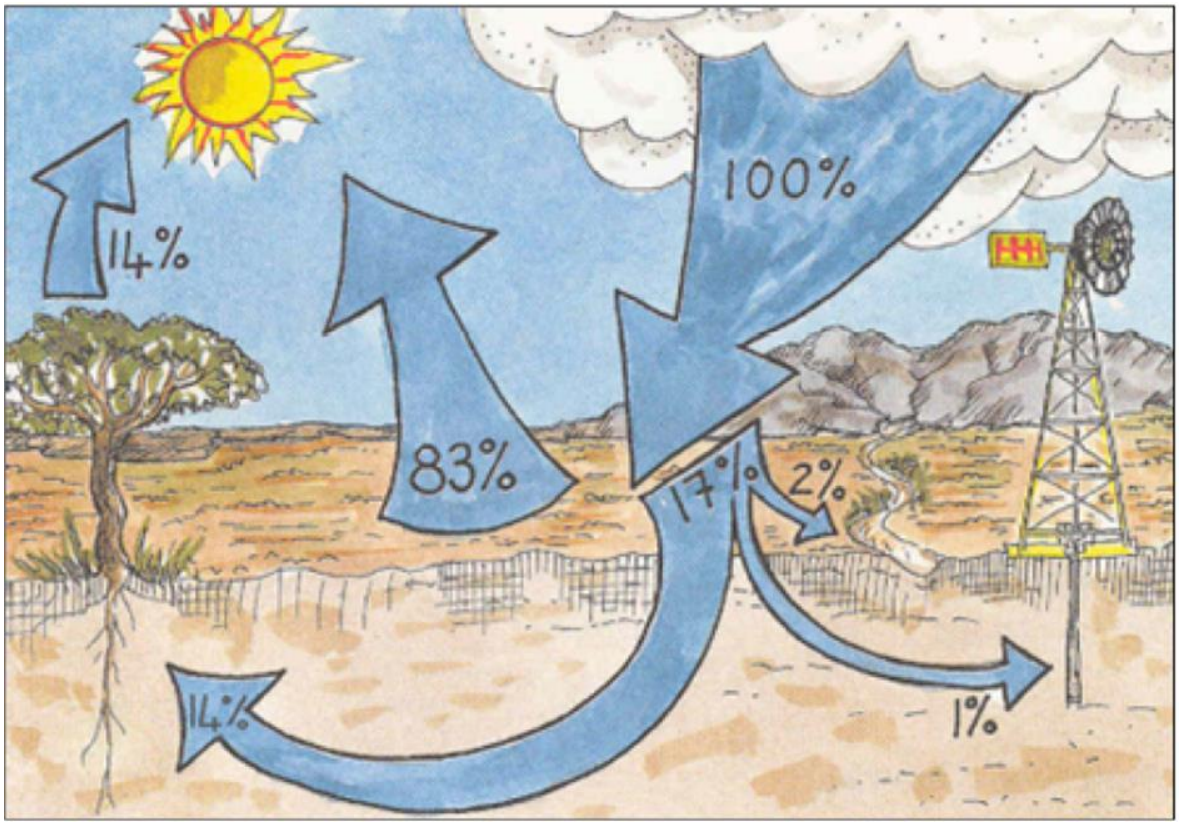

Figure 1: Hydrological cycle in Namibia
Source: IWRM Plan JV Namibia, 2010.

Namibia is bordered by the Cunene River and Kavango River in the north and the Orange River in the south. However, these perennial rivers are far away from the highly populated centres where the water demand is the highest. These rivers are also located far away from the country's mines, which are the largest users of water.

To address the water scarcity situation faced by the country, various measures have been put in place over the years. The national water provider (NamWater) has built dams to store water from various ephemeral rivers such as the Swakoppoort, Kuiseb and Kavango rivers. Water pipelines were laid to transport water from the dams to service reservoirs before being distributed to users. In 2010, AREVA Mining Company opened the largest seawater desalination plant in sub-Saharan Africa to meet its water needs and that of the coastal town of Swakopmund. A water scheme was proposed in the 1980s to pipe water from the Kavango River via a pipeline to Windhoek, but this option was very costly and hence did not materialise.

There is a need for a paradigm shift towards the holistic and integrated management of urban water, especially in populated centres such as Windhoek. The implementation of Integrated Urban Water Management (IUWM) is imperative. IUWM advocates for a holistic approach towards the management of water resources. The water scarcity situation has led to direct waste water reclamation for potable re-use in Windhoek for close to 50 years. In addition to the already implemented measures towards IUWM (including waste water reclamation), the City of Windhoek needs to explore more options that will contribute to IUWM processes in order to ultimately become a Water Sensitive City.

Water Sensitive Urban Design (WSUD) is a framework originally developed in Australia. This framework is aimed at achieving integrated water management through the application of WSUD options at various scales. WSUD is defined as: '*The process of integrating water cycle management with the built environment through planning and urban design*' (Morgan *et al*., 2013). WSUD can be achieved through urban designs that mimic the natural water cycle. It has been described as, '*A way of planning our cities to minimise water runoff and ensure any runoff causes the least amount of damage*' (ACT Government, 2014). It encourages the spatial integration between cities and catchments in order to contribute to solving the water management challenge.

The aim of this research was to establish the extent to which the concept of WSUD has been explored and implemented within the City of Windhoek by carrying out a review and gap analysis.

1.3 Research objectives and questions

1.3.1 Research aims

The research had the following objectives:

i) Determine the extent to which the concept of WSUD is advocated by the City of Windhoek

ii) Validate the extent to which the City of Windhoek has implemented WSUD

iii) Provide a detailed review of WSUD implemented within the City of Windhoek

iv) Identify existing gaps pertaining to WSUD within the City of Windhoek and make recommendations on how these can be filled.

1.3.2 Research questions

The following research questions were used to guide the research in achieving the above objectives:

1.3.2.1 Primary research question

To what extent is WSUD implemented within the City of Windhoek?

1.3.2.2 Secondary research questions

i) Is the planning and design of infrastructure in the City of Windhoek water sensitive?

ii) Are all the key stakeholders involved in the planning and designing of the urban infrastructure aware of the WSUD concept?

iii) How WSUD is currently incorporated in the planning and designing of infrastructure in the City of Windhoek, and how can it be improved to become a Water Sensitive City?

iv) Do the existing building regulations/standards advocate for WSUD?

1.4 Layout of dissertation

This chapter covered the research problem, outlined the research objectives and research questions, and gave an overall background to the problem under investigation. It introduced the concepts of WSUD and IUWM, thus laying the foundation for the rest of the report. The next chapter (Chapter 2) starts by unpacking literature on the concept of Water Sensitive Urban Design (WSUD) and then continues to discuss literature published on the water situation in Namibia and Windhoek in particular.

The literature review chapter is followed by Chapter 3 which outlines the research methods used to collect data for this dissertation. This data is presented and analysed in Chapter 4. Chapter 5, the final chapter of this dissertation, presents the conclusions based on the study and provides recommendations on how WSUD can be fully implemented within the City of Windhoek.

2. LITERATURE REVIEW

2.1 Introduction

According to Henning, Gravett and Van Rensburg (2005), a literature review is about finding a suitable method to explain a problem by utilising the existing body of knowledge of other researchers. This chapter therefore starts with an introduction of Namibia's Development Goals and national legislation governing access to safe drinking water as well as the sustainable management and utilisation of water resources within the country. It then continues by unpacking theoretical contexts of the WSUD concepts and tools as described by other researchers, and provides examples of cities where the concept is best practised and the factors that have contributed to their success. The chapter ends by providing an overview of the water situation in Windhoek. A literature assessment of the City of Windhoek Integrated Urban Water Management is provided.

2.2 National legislation and policies

2.2.1 Namibia's Developmental Goals (NDPs)

Like most African countries, Namibia is faced with the challenge of providing adequate and safe water to its rapidly growing population. This water situation is even worse in urban areas with high urbanisation rates. Post-independence, poverty reduction has been the core of Namibian national developmental policies and strategies. According to Van Rensburg (2006), the Poverty Reduction Strategy (PRS) was adopted in 1998 just two years before the introduction of the Millennium Development Goals (MDGs). This strategy was followed by a comprehensive poverty reduction action programme, which was implemented during the period 2001 to 2005.

Over the years, Namibia's national development strategies have evolved to focus more on sustainable development. The country's national development strategies comprise both long-term and short-term goals, and include Vision 2030, National Development Plans (NDPs) and the Harambee Prosperity Plan (HPP) (National Planning Commission, 2018). Vision 2030 forms the overarching framework for the national developmental strategies. So far, Namibia has prepared 5-year NDPs (NDP1 to NDP5), which are building blocks towards achieving Vision 2030 and the then MDGs, which have been superseded by the Sustainable Development Goals (SDGs) in 2015 (National Planning Commission, 2018). Vision 2030 was introduced in 2004, two years after the second National Development Plan (NDPII) was launched and is aligned with the global Sustainable Development Goals (Agenda 2030) (National Planning Commission, 2018).

The aim of SDG 6 (clean water and sanitation) is aimed at ensuring the availability and sustainable management of water and sanitation for all. Namibia has partly contributed towards this goal by providing access to safe drinking water to 98.3% of the urban population and 84% of the rural population by the end of the NDP4 period in 2016 (National Planning Commission, 2018).

According to the National Planning Commission (2018), Namibia's 5th National Development Plan (NDP5) was launched in 2017, based on the principle of sustainable development. One of the key goals set out in NDP5 is ensuring a sustainable environment (National Planning

Commission, 2017). NDP5 restates the water supply priorities in Namibia by putting emphasis on sustainable production and consumption of water resources resulting in improved access to safe drinking water. The targets set out in NDP5 are to increase the percentage of urban access to safe drinking water to 100% and rural access to safe drinking water to 95% by the year 2022 (National Planning Commission, 2017). NDP5 is thus a building block towards achieving the SDGs by the year 2030. The Harambee Prosperity Plan (HPP) (5-year plan), which was launched in 2016, serves as an accelerating tool for the implementation of the National Developmental Goals (Office of the President, 2016).

2.2.2 Other national legislation and policies

Namibia is considered the driest country in sub-Saharan Africa and is characterised by a semi-arid environment, with more than 80% covered by desert or semi-desert (Climate Technology Centre & Network, 2019). Due to the arid climate and high evaporation rates, the country has a long history of water scarcity. Namibia thus has an inherent water problem due to the scarcity and the vulnerability of water resources. The water problem therefore does not arise from the provision of infrastructure or services but rather from the scarcity and vulnerability of this precious resource. Hence, there is a need for an integrated approach towards water management due to the vulnerability and the finite nature of this resource.

Historically, the country has developed numerous plans, strategies and approaches, all attempting to reach the same overall goals, namely integrated and sustainable water use and management (CTCN, 2019). As such, the government and other stakeholders embarked on a variety of interventions, all leading to the sustainable use and management of water. The City of Windhoek (CoW), for instance, introduced the direct wastewater reclamation for potable use in 1968. More than two decades later, in 1994, the CoW implemented the Water Demand Management (WDM) policy. It was in this light that the Namibian government has developed the Integrated Water Resources Management Plan (IWRM Plan) in 2010, to provide guidance to the relevant stakeholders with regard to the implementation of IWRM.

The IWRM Plan acknowledges the country's dry climate and erratic rainfall patterns, and explains that the water scarcity challenge can only be addressed through a high degree of efficient water resource management. The IWRM Plan for Namibia is aimed at achieving a sustainable water resources management regime in order to contribute towards Vision 2030 (IWRM Plan JV Namibia, 2010).

The IWRM Plan highlights the need for the use of unconventional water resources to augment water supply (IWRM Plan JV Namibia, 2010). These resources include:

- The desalination of sea water
- The re-use of water for water parks and grounds
- The recycling of water used in industrial and mining processes
- The reclamation of water from waste water effluent
- The artificial recharge enhancement of aquifers
- The mixing of potable water and brackish water to improve quality

- Water demand management through the conservation of water by reducing usage and wastage.

Furthermore, the IWRM Plan provides actions and recommendations to ensure that the management of water resources takes into account climate change (IWRM Plan JV Namibia, 2010). Policies governing the water supply and management environment in Namibia, as stipulated in the 2019 NamWater Report, are outlined below (NamWater, 2019):

- The “new” Water Resources Management Act, No. 11 of 2013;
- The Namibian Water Policy White Paper, 2000;
- The Water Resources Management Act, 2004;
- The Draft Water Resources Management Act (Final Version 2011);
- The Namibia Water Corporation Act, 1997;
- The National Water Policy, 2000;
- The Water Supply and Sanitation Policy, 2008;
- The Local Authority Act, 1992, and the Local Authority Water Supply Regulations;
- The Environmental Management Act, 2007, and the accompanying regulations;
- The Decentralisation Policy, 1997.

Over the past few decades, some of the policies governing the water supply and management environment have been reformed with emphasis on the IWRM Plan, as discussed below:

The National Water Policy White Paper of 2000 provides a policy framework for equitable access to water resources, sustainable water resources management and water services, thus providing a conducive environment for IWRM (CTCN, 2019). The National Water Policy White Paper highlights the need for Namibia to adopt an integrated multi-disciplinary approach towards water resources management, which takes cognisance of issues such as decentralisation, social equity, ecological protection and economic growth (CTCN, 2019).

To create an enabling environment for the implementation of the IWRM Plan, the Water Act, No. 54 of 1956, was replaced by the Water Resources Management Act (WRMA), No. 24 of 2004 (CTCN, 2019). The WRMA, No. 20 of 2004, highlights the need for water resources to be managed, developed, protected, conserved and used in ways that ensure equitable access to water resources for all citizens (CTCN, 2019). The WRMA further emphasises that an integrated approach is required in the planning and management of surface and ground water resources, taking cognisance of socioeconomic and environmental dimensions.

According to the CTCN report, the WRMA (2004) lacked clarity in terms of identifying the roles and responsibilities of various stakeholders with regard to the implementation of the goals of the IWRM Plan. As a result, the WRMA (2004) was replaced by the Water Resources Act of 2013.

The CTCN report stated that the goal of the WRMA (2013) is to promote sustainable development based on the principles of the IWRM Plan, taking socioeconomic and environmental dimensions into account. Furthermore, the WRMA (2013) acts as an enabler

to ensure the management, protection, development, use and conservation of water resources. The WRMA (2013) assigns the responsibilities for ensuring the sustainable use and development of water resources to the regional or basin-level authorities to ensure that local people are involved in watershed management and planning. The WRMA (2013) recommends the establishment of a Water Advisory Council that will be tasked with advising the ministry on issues pertaining to water policy development and review, and water resources management.

The Water Supply and Sanitation Policy (WASP) was first adopted in 1993, but was later replaced by the Water Supply and Sanitation Policy (2008) (CTCN, 2019). The overall objective of the WASP (2008) is to ensure affordable access to water supply and sanitation services to every citizen.

The WASP (2008) provides guidance in terms of priority ranking that is applicable in times of water shortages, with domestic water use taking precedence followed by water for economic activities.

2.3 History of Water Sensitive Urban Design (WSUD)

The fragmented management of the urban water cycle has led to negative impacts. Integrated Urban Water Management (IUWM) responds to this fragmented approach by advocating for a more holistic management approach towards the urban water cycle. According to Lottering (2011), IUWM can be considered as the original umbrella concept from which WSUD has emerged. Worldwide, countries have responded to the IUWM concept through the implementation of various management strategies, with WSUD emerging from Australia. Some closely allied management strategies that emerged in response to IUWM include:

i) **USA – Low-Impact Development (LID)**: This is the American equivalent of Australia's WSUD but with a focus on stormwater management.

ii) **New Zealand – Low-Impact Urban Design and Development (LIUDD)**: This is the equivalent of WSUD in New Zealand.

Like Australia, the UK and South Africa has adopted the terminology (WSUD), with Sustainable Drainage Systems (SuDs) being a subcomponent of WSUD and refers to storm water management. Since the focus of this research was on WSUD, this will now be discussed in more detail.

2.3.1 Water Sensitive Urban Design: What is it and why is it important?

Water Sensitive Urban Design (WSUD) is a framework originally developed by the Australians aimed at achieving integrated water management through the application of WSUD options at various scales. It is defined as: *'The process of integrating water cycle management with the built environment through planning and urban design*' (Morgan *et al*., 2013). Alternatively, WSUD can be seen as *'a way of planning our cities to minimise water runoff and ensure any runoff causes the least amount of damage*' (Australian Capital Territory Government, 2014). According to the City of Melbourne's Water Sensitive Urban Design Guidelines (2009), WSUD is a holistic approach where all water streams are considered as a resource as opposed to the traditional approach that focuses on getting stormwater away from the source as fast as

possible. WSUD can be achieved through urban designs that mimic the natural water cycle, allowing for the spatial integration between cities and catchment and, as a result, contributing to solving the water management challenges. Since its implementation in Australia, the WSUD concept has been adopted around the world and has evolved to include stormwater as well as all components of the water cycle such as rainwater, wastewater (including black water and greywater) and drinking water, in addition to natural freshwater systems (Barraclough & Lucey, 2014).

When urban development takes place, virgin land is increasingly covered with 'hard' surfaces such as pavements, roof tops, roads and sidewalks, which are all impermeable surfaces. When it rains, stormwater rapidly runs off these hard surfaces, washing off pollutants that pollute streams and often results into flash flooding, the erosion of water courses and harm to the nearby vegetation (ACT Government, 2014). This is in contrast to the natural water cycle, which allows rainwater to soak through the soil while water treatment occurs concurrently through natural processes before the rain water reaches the aquifers.

The aim of WSUD is to integrate the urban water cycle into urban planning and design by 'mimicking' the natural water cycle processes. Figure 2 illustrates the different water cycles that can exist in a natural environment and in an urban setting.

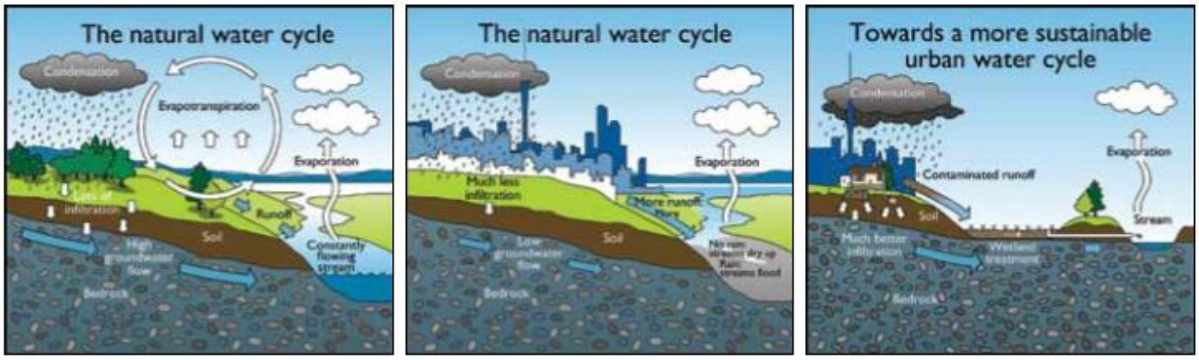

Figure 2: The natural water cycle, urban water cycle, and a more sustainable urban water cycle
Source: Barraclough et al., 2014.

WSUD is aimed at achieving sustainable urban water management solutions for urban developments and ultimately Ecologically Sustainable Development (ESD) (City of Mooney Valley, 2014). It is impossible to achieve ESD if the three urban water streams (stormwater, wastewater and water supply) are treated in isolation. The urban water cycle is one system and needs to be treated as such. According to Wong (2007), WSUD brings about ESD by serving as 'a framework for integrating the holistic management of the three urban water streams'. It brings 'sensitivity' to water into urban design.

Water 'sensitivity' is a novel approach in urban water cycle management that gives due prominence to water in urban design and can be achieved by engaging professionals from various fields that are associated with the provision of water services as well as the protection of the aquatic environment in an urban setting (Ashley *et al*., 2013). Professionals involved include environmentalists, planners, engineers and architects.

There is a need to clearly define urban design so as not to cause confusion among practitioners. According to Ashley *et al*. (2013), Water Sensitive Urban Design (WSUD) comprise of two components: 'water sensitivity' and 'urban design'. Wong (2007) explained urban design in the following way:

> *Urban design is a well-recognized field associated with the planning and architectural design of urban environments, covering issues that have traditionally appeared outside of the water field but nevertheless interact or have implications to environmental effects on land and water. WSUD brings 'sensitivity to water' into urban design, in other words it aims to assure that water is given due prominence within the urban design processes. The words 'Water Sensitive' define a new paradigm in integrated urban water cycle management that integrates the various disciplines of engineering and environmental sciences associated with the provision of water services including the protection of aquatic environments in urban areas. Community values and aspirations of urban places necessarily govern urban design decisions and therefore water management practices. Collectively WSUD integrates the social and physical sciences*.

WSUD is thus the process aimed at achieving a 'water-sensitive city' rather than an end. From a wider perspective, WSUD is a tool that can be used to achieve ESD. ESD deals with a wide spectrum of issues that concerns sustainable development. WSUD is specifically concerned with the interaction between the urban built form and the integrated urban water cycle management (Wong, 2007). Integrated urban water cycle management aims at "*water conservation, pollution control of waste water and storm water and mitigation of the effect of increased flow as a result of catchment urbanization*" (Wong, 2007). The three integrated urban water management objectives can be achieved through the installation of various WSUD elements at various scales, as indicated in Figure 3.

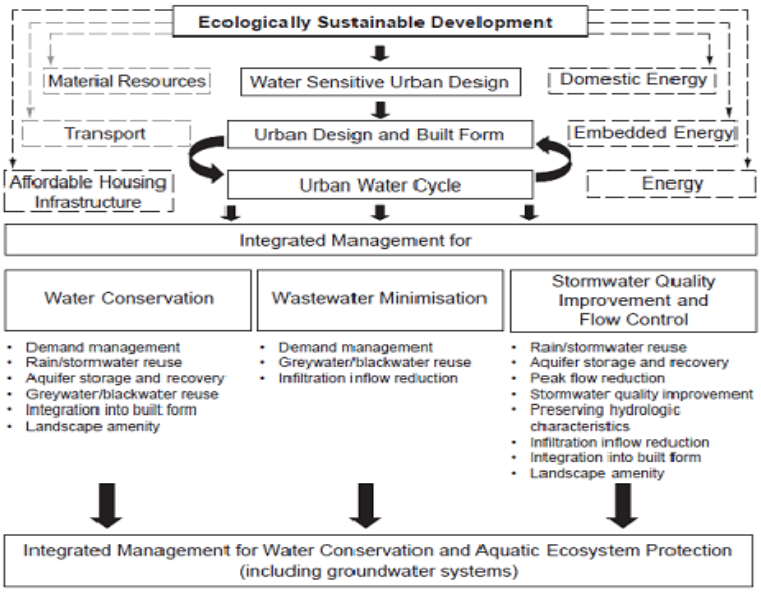

Figure 3: The interaction between Ecologically Sustainable Development (ESD), Water Sensitive Urban Design and the urban water cycle

Source: Wong, 2007; adapted from Ecological Engineering, 2003, Australian Runoff Quality, Engineers Australia, 2006.

2.3.2 Water Sensitive Urban Design: What are the benefits?

WSUD emphasises the importance of stormwater as a valuable resource as opposed to it being a *'nuisance'*, and waterways as a valuable asset (City of Moonee Valley, 2014). According to Wong (2007), WSUD elements have the benefit of both reducing water demand and reducing the amount of pollutants in stormwater. Stormwater harvesting (SWH) has both the benefits of water conservation and stormwater management. The WSUD approach to stormwater management not only brings 'water sensitivity' into urban design, it also has the benefit of enhancing social amenity, i.e. the creation of new green public parks as well as the preservation of environmental diversity.

According to Wong (2007), integrating urban water management with urban planning and design is multi-dimensional and includes:

- The integrated management of the three urban water streams of potable, wastewater and storm water
- The integration of the scale of urban water management from individual allotments and buildings to precincts and regions
- The integration of sustainable urban water management into the building form, incorporating architecture, landscape architecture and public art
- The integration of structural and non-structural sustainable urban water management initiatives.

The integration of the three components of the urban water cycle addresses the main objectives of IUWM, namely water conservation, wastewater minimisation and stormwater quality improvement and quality control (Wong, 2007). This approach promotes the use of alternative water sources guided by a 'fit-for-purpose' approach. It entails stormwater harvesting and treatment, greywater recycling, and treated greywater reuse.

To achieve ESD, WSUD options must be implemented across various spatial scales (at site, precincts and on regional level) (Wong, 2007). However, although WSUD options are implemented at various scales, they share the same design, operation approach and philosophy. Hence, they can be combined to provide a strategic framework for integrated catchment management.

According to Armitage *et al.* (2014), all natural systems take time to break down microbiological pollutants. Hence, care needs to be taken to limit the amount of pollutants brought into the system. This can be achieved by integrating WSUD tools/options into the built environment, starting at the individual household / building level (Figure 4).

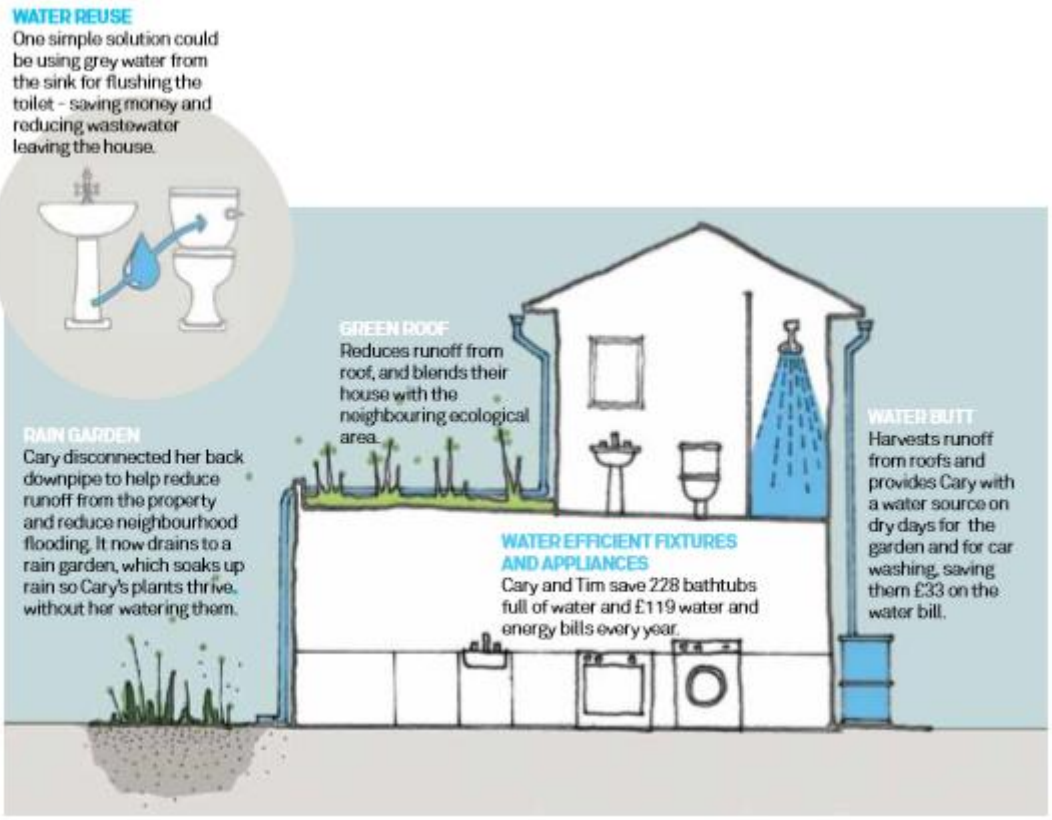

Figure 4: Water Sensitive Urban Design (WSUD) at household level
Source: Morgan et al., 2013.

The plumbing system can be configured in such a way that greywater is collected from showers, wash basins and baths (Wong, 2007). This can be treated and pumped back for toilet flushing. Roof gardens or bio-retention systems can be used to capture roof run-off. Alternatively, rainwater can be collected and stored into the architecturally designed water tanks incorporated into the building and used for gardening or other non-potable uses.

Sustainable Drainage Systems (SuDS) is the component of WSUD that deals with the sustainable management of stormwater. Armitage *et al*. (2014) pointed out that the management of stormwater in South Africa is currently focused on getting the stormwater away from the source as fast as possible – with little or no effort to preserve the environment. This traditional way of stormwater management has caused negative impacts on the environment. Stormwater harvesting (SWH), as a component of SuDS, is defined as '*the collection, treatment, storage and use of storm water run-off from urban areas*' (DECNSW, 2006, in Armitage *et al*. 2014). Various options are available for SWH that apply at different scales. These options include tank storage, open storage and managed aquifer recharge and recovery (MAR&R) (Armitage *et al*., 2014). Tanks may be used to collect and store runoff from a small catchment, such as a single roof. On the other hand, open storage, such as provided in lakes, collects water from much larger catchments. MAR&R is effected through the intentional collection and recharge of aquifers by boreholes or infiltration ponds.

One of the benefits of SuDS is the preservation of Ecosystem Goods and Services (EGS), both in terms of ecological functioning and human livelihoods (Armitage *et al*., 2014) by preventing, minimising and mitigating the negative environmental impacts caused by

urbanisation through increased demand of water resources, increased stormwater flow and the increased pollution of water bodies (City of Moonee Valley, 2014). SuDS benefit the environment through:

i) Reducing the size of floods that occur as a result of the urbanisation. Urbanisation often increases the runoff rates by 20 to 50% compared with natural conditions. Peak flows can be up to 6.8 times more than that before development (Armitage *et al*., 2014).

ii) Improving water quality in waterways and catchment resulting from improved stormwater quality as SuDS have the ability to treat stormwater before it is released into aquifers and streams.

iii) Increasing water conservation. Rainwater tanks can offer the benefits of both water conservation and on-site treatment.

iv) Establishing wetlands, treatment trains, etc. to offer the benefit of 'improved habitat and biodiversity*'* (City of Moonee Valley, 2014).

v) Harvesting rainwater and reusing grey water to reduce the demand on the potable water supply.

vi) Facilitating reduced energy consumption as green roofs offer insulation within buildings and as a result save energy.

SuDS can benefit the *'urban setting'* by:

i) **Aesthetics**: The aesthetics of an area is enhanced through the preservation of the natural environment. For example, wetlands result in increased vegetation and aquatic elements, and are often used as amenities within an urban environment.

ii) **Improved market value**: The benefits that SuDS bring to the environment (preservation of the natural environment, water conservation, improved aesthetics, etc.) can add to the market value of property, making developments more desirable.

iii) **Optimisation of urban land use**: Areas that are unsuitable for residential development through the implementation of wetlands can be used as an amenity offering recreational opportunities to the public. A good example of this urban use is the Century City's Intaka Island in Cape Town, South Africa.

Figure 5 illustrates the benefits of WSUD within an urban setting.

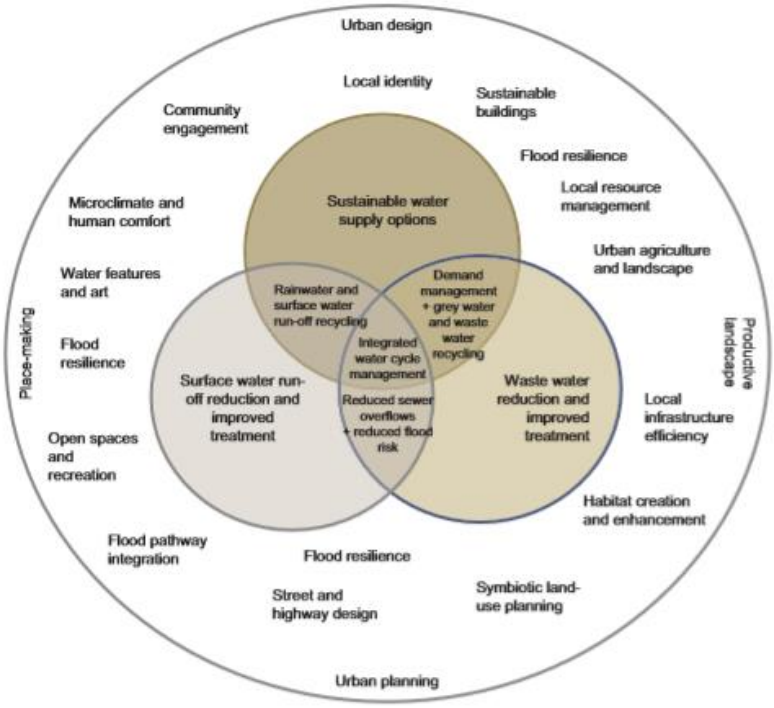

Figure 5: The benefits of WSUD in an urban setting
Source: Ashley et al., 2013.

2.3.3 Water Sensitive City

A Water Sensitive City (WSC) is a city where water is given due prominence in urban planning and design (Armitage *et al*., 2014; Wong, 2007). WSUD was first introduced in Australia in 1990 with the aim of addressing the water challenges facing that country. Over the years, the WSUD framework has evolved with the concept of a WSC as proposed by Brown, Keath and Wong (2008) at the 11th International Conference of Urban Drainage. Figure 6 shows the evolution of a WSC as formulated by Brown, Keath and Wong (2009).

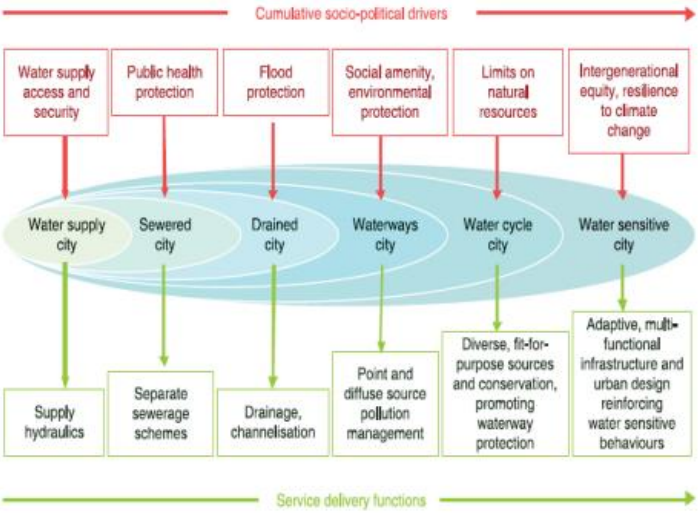

Figure 6: The evolution of the water-sensitive city
Source: Brown, Keath and Wong, 2009.

Armitage *et al*. (2014) explored water sensitivity in a South African context and argued that even though Brown's framework is relevant to South Africa and may help solve the country's water challenges, it still needed to be contextualised to suit South Africa's developmental challenges. In their report titled *Water Sensitive Urban Design for South Africa*, they revised the term WSC as well as WSUD to suit the South African context. South Africa is facing unique developmental challenges, some of which are caused by the 'legacy of apartheid', and therefore any framework developed should account such challenges. The apartheid planning had led to dense settlements on the outskirts of cities, making it difficult to service those areas with sustainable water services. Thus, the term 'city' in WSC was changed to Water Sensitive Settlement (WSS) to include a wider range of settlement types (Armitage *et al*., 2014). A WSS is therefore a settlement where water takes prime importance, while in the South African context, 'water sensitivity' is:

> *the management of the country's urban water resource through the integration of various disciplines of engineering, social and environmental sciences whilst acknowledging that: RSA is water-scarce; access to adequate potable water is basic human right; the management of water should be based on participatory approach; water should be recognized 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.*

For South Africa to move from 'water wasteful' to 'water sensitive', Armitage and his co-researchers (2014) recommended that South Africa moves away from the conventional way of managing water towards a holistic and 'integrated systems approach'. The country needed to transition from the traditional approach of water system design – which was based on a linear system of source, treat, transport, distribute, collect, treat and dispose – and which has led to the fragmentation of the management of the urban water cycle. WSSs can only be achieved if the urban water cycle is managed as a single system consisting of circular causes and effects. Water management challenges are complex and cannot be solved by simply applying a linear systems approach. Systems consisting of circular causes and effects assume that everything in the world is linked, thus ensuring a holistic approach towards water management challenges.

South Africa is currently experiencing fragmentation within its water cycle management. For example, water-related responsibilities are often allocated to different departments within municipalities. Stormwater might be allocated to the roads department, while water supply and wastewater treatment are managed separately (Armitage *et al*., 2014). There is a need to integrate all the elements of the urban water cycle; WSUD can only be achieved if the silo management of the urban water cycle and other impediments to integrated urban water management have been addressed. Due to the complex and multi-dimensional nature of the South African water problem, WSUD can only be achieved by engaging stakeholders from various institutions through a learning alliance, who work together towards solving the South African water problem. Furthermore, Armitage *et al*. (2014) argued that both informal and formal settlements should be taken into consideration when implementing WSUD. Figure 7 shows how the WSUD framework can be adapted to suit the South African context.

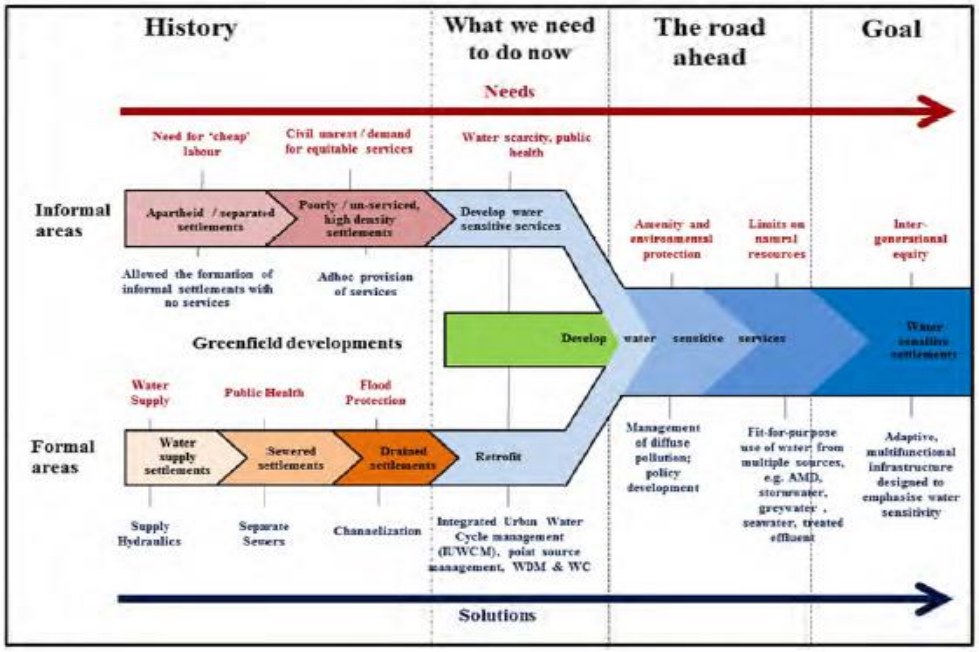

Figure 7: Framework for Water Sensitive Settlements in RSA, 'Two histories, one future'
Source: Armitage et al., 2014, adapted from Brown et al., 2009.

In essence, 'Water *Sensitive Urban Design is the process. Water sensitive places are the outcome*' (Morgan et al., 2013).

WSUD also needs to be implemented across all the spatial scales (at site, precincts and on regional level) (Wong, 2007). The elements work together to provide for integrated catchment management. Although WSUD options are applied at various scales, most of the elements share the same design, operation approach and philosophy (Morgan *et al.*, 2013), as illustrated in Table 1.

Table 1: Inter-relationships between site-precinct-regional WSUD initiatives
Source: Wong, 2007

Local	Precinct	Regional
Planning		
• Allotment density and layout	• Local street layout	• Major road layout • Public open space and multi-use corridor
Water Conservation		
• Rainwater tank	• Stormwater storages/pond • Aquifer storage and recovery	• Stormwater storages/pond • Aquifer storage and recovery
Stormwater Quality		
• On-site retention (infiltration) • Porous pavement • Sand filters • Bio-retention planters • Rain garden • Vegetated buffer	• Precinct-wide infiltration basins • Porous pavement • Sand filters • Bio-retention swales • Bio-retention basin • Vegetated swales • Urban forest • Constructed wetlands	• Riparian buffer • Natural channels • Urban Forest • Constructed wetlands
Stormwater Detention		
• On-site detention	• Retarding basins • Ponds	• Retarding basins • Lakes

WSUD has been successfully implemented in Australia with the focus being mainly on Sustainable Drainage Systems (SuDS) (Myers *et al*., 2013). According to Lottering (2011), WSUD can be grouped into four main categories, namely:

- Stormwater management
- Demand reduction techniques/water demand management
- Water re-use, and
- Green roof installation.

The following WSUD practices are commonly found:

- Grey water/black water reuse
- Roof gardens
- Storm water harvesting
- Rain gardens
- Permeable pavements
- Swales and buffer strips
- Gross pollutant traps
- Bio-retention systems
- Waste water reclamation
- Constructed wetlands
- Retention ponds.

Examples of typical practices are illustrated in Figure 8.

Figure 8: Wetlands and bio-retention systems
Source: City of Melbourne, Water Sensitive Urban Design Guidelines.

Stormwater *management*

WSUD stormwater management (SuDS) acknowledges the fact that stormwater is a valuable resource and that it entails the management of both the quality and quantity of the stormwater (Lottering, 2011). The management of stormwater quality can be achieved through the installation of WSUD elements such as buffer strips and constructed wetlands, all aimed at removing pollutants from the water. A *'treatment train'* is an approach used to effectively treat stormwater by making use of two or more treatment activities in succession. Making use of multiple treatment options in a row allows the stormwater to be treated numerous times and in different ways, effectively removing pollutants. It is important to note that no single stormwater control measure or activity can remove all pollutants from stormwater, hence the need for the implementation of a treatment train. A *'treatment train'* can further be classified into primary and secondary treatments.

Primary treatment can constitute bio-retention swales (channels) made of vegetation and grass to allow filtering out of large sediments. According to Lottering, swales are low-lying areas that allow for infiltration of stormwater and movement of stormwater to a collection point. Bio-retention swales are designed so that water first moves through vegetation (which removes some micro-pollutants) before proceeding into the underlying gravel-filled trench (Lottering, 2011).

Primary treatment also caters for solid waste management. Gross pollutant traps are used to trap pollutants such as paper, plastics and garden waste. These pollutants are transported by the stormwater system into receiving waters such as rivers, where they can pose a threat to the aquatic environment. To prevent gross pollutants from entering into water bodies, stormwater systems must be installed with various stormwater trappings (Lottering, 2011). According to Armitage and Marais (2004), the problem of urban litter in the drainage system can only be addressed by implementing an integrated catchment strategy, as illustrated in Figure 9 below.

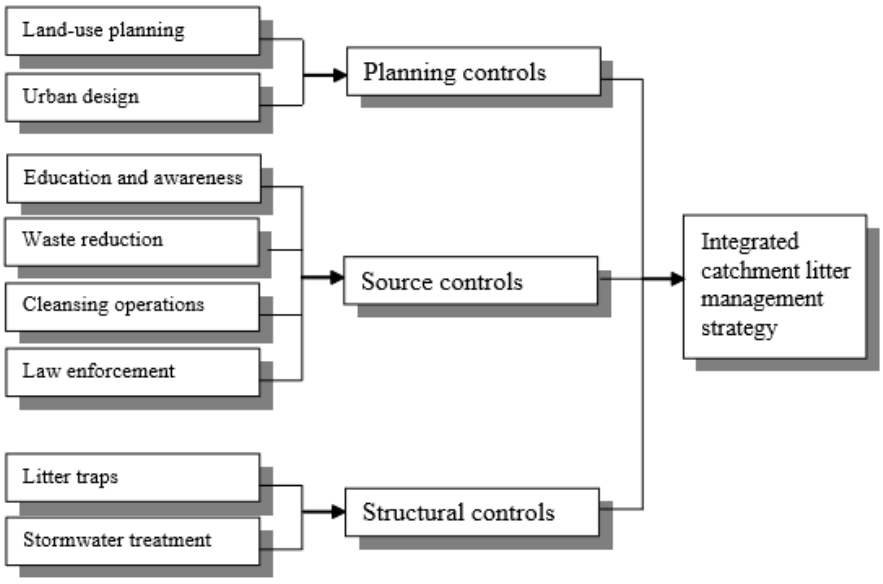

Figure 9: Components of an integrated litter management strategy
Source: Armitage and Marais, 2004.

As is evident from Figure 9 above, litter traps and stormwater treatment form part of structural controls. A series of litter traps are required within a drainage system to allow for the effective removal of litter from the drainage system as effective litter removal cannot be achieved by a single measure.

Sedimentation basins and bio-filtration basins are found downstream of a treatment train and can be referred to as secondary treatment. Sedimentation basins are designed to slow down flow rate and to further remove sediments that could not be removed upstream (Brisbane City Council, 2006). Bio-filtration basins are designed to remove finer particles of sediments and nutrients. This can be achieved by allowing water to pond on top of a garden, allowing it to slowly filter down the soil. By so doing, the fine sediments and nutrients are filtered out.

According to Lottering (2011), the quantity of water and pollutants entering into the stormwater system can be managed in four ways. The first option is aimed at preventing extra water from irrigation systems from entering into the stormwater system. This can be achieved through the installation of rain sensors that stop irrigation when it is raining. Rain water harvesting is a second form of stormwater quantity management, entailing the harvesting of rainwater from roof tops at household level and the storage of it for later use. This practice was commonly used by Australian rural dwellers (Lottering, 2011). However, the water scarcity situation in urban areas necessitates the use of rainwater tanks.

A third way of managing stormwater quantity is through drought-tolerant landscaping practices which are aimed at reducing irrigation run-off. The first three management practices are known as '*source control'* and, apart from quantity management, they also prevent pollutants from entering water bodies and ground water (Lottering, 2011).
The fourth stormwater management practice suggests that stored water be released into the ground to recharge groundwater, often referred to as Managed Aquifer Recharge. The water is stored underground for use during dry seasons.

Water re-use

WSUD was initially focused on stormwater management but has evolved over the years to include the management of potable water and wastewater. Wastewater can be reclaimed and re-used for either potable or non-potable use, such as the case in Windhoek. Grey water refers to the water from bathroom sinks, showers and laundry that can be re-used to flush toilets, for instance.

Green roof installation

According to Lottering, (2011), a green roof is a special kind of roof that consists of vegetation grown on a medium that supports plants, often of shallow depths ranging from 20 to 30cm. The benefits of green roofs include that of improved stormwater management. Green roofs retain rainwater and filter sediments and heavy metals from the water. This means that less water will end up in the stormwater system, thus reducing the cost of building and maintaining stormwater infrastructure. Green roofs also serve to insulate buildings, which results in reduced energy use and thus lower greenhouse gas emissions (Lottering, 2011). Another benefit of green roofs is increased aesthetics, which in turn increases property value.

2.3.4 Barriers, challenges and drivers to WSUD implementation

In addition to technical knowledge on WSUD there are other factors that need to be taken into consideration to ensure the successful implementation of WSUD. The legislation of WSUD via supportive acts, policies, regulations, standards and/or guidelines is a critically important enabler of WSUD implementation. Indeed, according to Roy *et al*. (2008), in countries such as New Zealand, the United States and the United Kingdom where WSUD equivalents are mostly practised, increased awareness and inclusion of WSUD in their policies is the main driver to their adoption. Myers *et al*. (2013) noted that having documented legal frameworks makes it much easier to enforce and legitimise WSUD in the eyes of consultants, government agencies, professional organisations and property developers. Conversely, the absence of such policies is a barrier to WSUD implementation.

Other drivers of WSUD with local governments in Australia, according to Myers *et al*. (2013), include funding availability, cost-effectiveness, improved amenities, local champions, and consultants with expertise in WSUD design and policies.

According to Gardiner and Hardy (2005), WSUD is often perceived as expensive – and implementation impossible without the necessary financial resources. Due to differences of opinion pertaining to WSUD cost-benefit analyses, professionals can struggle to make the case for these innovative practices. Nevertheless, while costs may be higher in the short term, advantages such as better environmental outcomes and preservation of the quality of life for communities often become significant benefits in the long run. This misconception is also attributed to lack of understanding of the WSUD concept.
One of the participants interviewed in the Myers *et al.* study (2013), illustrated this as follows: "*People need to understand, you cannot expect everything out of WSUD – there is often lack of clarity on what WSUD objectives we are trying to achieve*." This can be a reason for the lack of large-scale uptake of WSUD globally. According to Brown (2005), the low adoption of WSUD and sporadic variation is attributed to the fact that urban water agencies, policy makers and developers are unwilling to take the risk of embracing new technologies such as WSUD in their jurisdictions. The majority are still stuck in conventional water management practices.

On the other hand, according to Roy *et al*. (2008), technical expertise and knowledge of WSUD is lacking even in Europe where WSUD implementation is more advanced than in the rest of the world. Consultants and professional associations that were interviewed by Myers *et al*. (2013) acknowledged that, even among consultants and engineers, the depth of WSUD knowledge varies, particularly regarding more complex WSUD projects, and was often linked to the practical experience of individual professionals. This suggests, as recommended by Taylor (2008), that WSUD champions are vital for driving WSUD implementation.

2.4 Water management in Windhoek

2.4.1 Overview of the water situation in Windhoek

Windhoek is situated in the central highlands of Namibia and is characterised by mountainous terrain. The geographical and hydrological nature of the capital city exacerbates the water scarcity situation, resulting in a water management challenge. The river systems in the surrounding areas of the capital city drain away in all directions from the city, resulting in limited perennial water resources (Tredoux, Van Der Merwe & Peters, 2009). Windhoek has an

average annual rainfall of approximately 370mm, with high evaporation rates ranging from 3000 to 3500mm per annum. The closest perennial river is the Kavango River located 700km away. The city is situated 300km from the ocean and is about 1600m above sea level.

Due to fluctuations and uncertainties in the rainfall patterns, long periods of drought are frequently experienced. As a result, the water supply from reservoirs and wells cannot be relied upon. In addition, the distance required to transport water from permanent water bodies to Windhoek makes this option uneconomical. This calls for the need to look at other sources of water to sustain the city's rapidly growing population. According to the 2011 census, Windhoek's population was 326,000, and with an annual growth rate of 4.4% it was estimated to increase to approximately 400,000 in 2018. With the rapid population growth and the scarcity of water resources, there is an urgent need to look at alternative water sources and effective water management to help ensure water security and sustainable water supply.

Windhoek's water supply is a blended mixture of water from surface dams, boreholes and reclaimed water. Windhoek's surface water is supplied by NamWater, which is a national potable bulk water supplier. NamWater makes use of a "three-dam system" (the Omatako, Swakoppoort and Von Bach dams) to supply water to the Central Area of Namibia (CAN), including Windhoek (City of Windhoek, 2019).

The city's water supply in 2018 comprised 30% reclaimed water, 16% aquifer water (boreholes) and 54% surface water (City of Windhoek, 2018). Figure 10 below illustrates the sources of water supply as measured until June 2018.

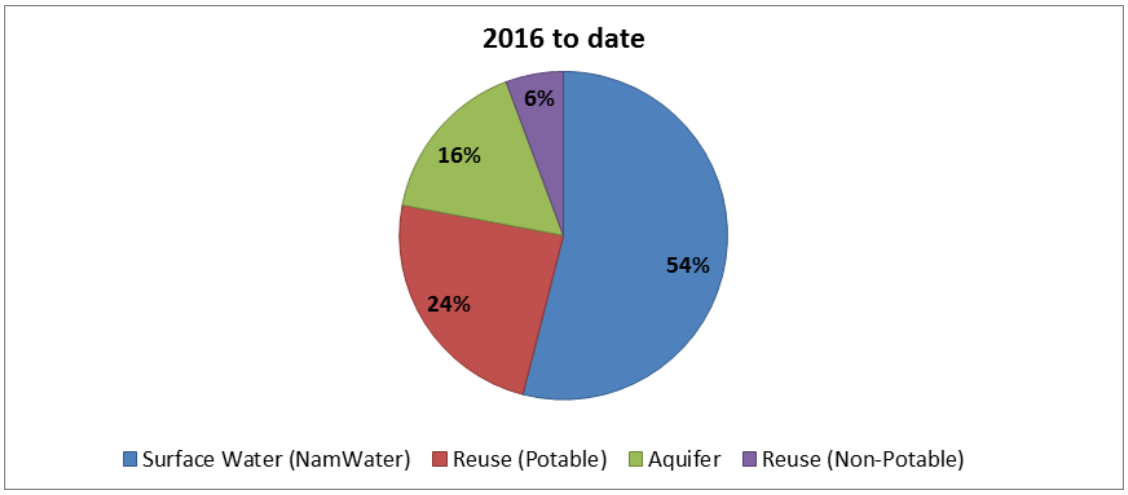

Figure 10: Water supply to the City of Windhoek
Source: City of Windhoek, 2018.

The three major dams that supply water to the City are the Omatako Dam in the north, Swakoppoort Dam in the west and the Von Bach Dam in the central area, as indicated in Figure 11 below (Van Rensburg, 2006).

Figure 11: Location of main water supply dams
Source: Menge, 2012.

2.4.2 Integrated Urban Water Management (IUWM) in Windhoek

According to Armitage *et al*. (2014), the water crisis in most developing countries is mainly due to the lack of effective water management caused by the fragmented management of the urban water cycle by the responsible parties. As a result, there is an ever-increasing gap between water supply and demand. This calls for a paradigm shift in urban water management. Integrated Urban Water Management (IUWM) is an approach towards a new paradigm of managing water with the goal of achieving Ecologically Sustainable Development (ESD). Jacobsen *et al*. (2013) stated that, '*Integrated urban water management (IUWM) seeks to develop efficient, flexible urban water systems by adopting a holistic view of the urban water cycle (water supply, sanitation and storm water management) in the context of a wider watershed'*. Similarly, UNEP (2003) defined IUWM as: '*The practice of managing freshwater, wastewater and stormwater as links within the resource management structure, using an urban area as the unit of management*.'

It is important to note that the urban water cycle is one system and that it should thus be managed holistically (Jacobsen *et al*., 2013). It comprises three main components, namely water supply, stormwater and wastewater. Water scarcity requires an integrated approach towards water management across various scales that include households, neighbourhoods, cities, catchments and possibly even transboundary (Jacobsen *et al*., 2013). It also requires an integrated approach across economic, social and environmental domains as well as across government and private institutions.

According to Awiti (2013, in Jacobsen *et al*., 2013): '*Meeting urban water needs in the twenty-first century will require a paradigm shift. Nineteenth century supply-side solutions alone will*

never balance the ever-growing demand for water driven by rapid urbanization, shortage of surface and ground water due to climate change and competition from agriculture.'

Jacobsen *et al*. (2013) proposed four ways in which new approaches to urban water management can be promoted, developed and implemented in African cities:

i) Increase the use of integrated urban water management (IUWM) in project planning and design, drawing experience from other regions

ii) Generate more knowledge about the institutional requirements for IUWM

iii) Promote pilot projects to demonstrate IUWM in practice, and

iv) Develop learning alliances for IUWM.

The three departments within the City of Windhoek that deal with urban infrastructure planning and design – namely Infrastructure, Water & Technical Services; Urban & Transport Planning; and Economic Development – are depicted in the organogram below (Figure 12):

Figure 12: The organogram for the City of Windhoek
Source: City of Windhoek, 2019.

It is thus imperative that the relevant departments involved in the planning and design of infrastructure collaborate to ensure effective Integrated Water Management within the City of Windhoek.

Over the past 50 years, the City of Windhoek (CoW) has become well known for its reclamation of waste water for potable re-use. Windhoek has implemented various measures aimed at sustainable water management. These include Water Demand Management (WDM), Managed Aquifer Recharge (MAR) and water reclamation through the New Goreangab Water Reclamation Plant (NGWRP) and the Old Goreangab Water Reclamation Plant (OGWRP).

With a growth rate of 4.4%, the Windhoek population is estimated to grow to about 700 000 by the year 2031. This will continue to put strain on the water infrastructure, presenting ever greater challenges to the city as far as water supply and management is concerned. There is thus a need for the city to implement new measures to prevent a possible water crisis and transform into a Water Sensitive City.

2.4.3 The Goreangab Water Reclamation Plant (GWRP)

Almost 50 years ago, the water scarcity situation in Windhoek led to direct waste water reclamation for potable re-use in the city. Up until 1968, Windhoek's water supply consisted of water from boreholes and the Von Bach Dam. Due to the growing water demand over the years and poor rainfall, the city could no longer rely on water from the Von Bach Dam. As a result, the CoW had to introduce alternative sources of water supply. The construction of the Goreangab Water Reclamation Plant (GWRP) was considered as the most economically viable option. The initial plant (OGWRP) was commissioned in 1968. The OGWRP had an initial capacity of 4,800 m^3/day, which accounted for 30% of the water demand at the time. It was used to treat water for potable use until 2002 (CoW, 2018; Van Rensburg, 2006). In 2002, the New Goreangab Water Reclamation Plant (NGWRP) was commissioned with an initial capacity of 21,000 m^3/day. The NGWRP was designed to cater for up to 34% of the water demand, and treats domestic sewage for potable use. Currently, the NGWRP accounts for about 26% of Windhoek's water supply (CoW, 2018). Since 2002, the OGWRP has treated domestic sewage for use in the irrigation of parks, cemeteries and sport fields, and currently provides about 6% of Windhoek's water supply.

2.4.4 The dual pipe system

The dual pipe system was implemented between 1990 and 1992 with the aim of distributing semi-purified sewage for the irrigation of sports fields, parks and cemeteries within the city. After the construction of the NGWRP in 2002, the OGWRP was connected to the dual pipe system to supply unrestricted water to be used for irrigation purposes while simultaneously feeding the NGWRP with semi-purified water to be further treated for potable use (Van Rensburg, 2006). Approximately 1.44Mm^3 per annum of irrigation water was produced in 2002. Over the past 12 years, this amount has increased to approximately 1.78Mm^3 per annum. According to Burger (2004, in Van Rensburg, 2006), the rate of production of semi-purified water is limited, depending on the availability of purified effluent with potable water taking priority over irrigation water. The dual pipe system takes pressure off potable water demand during summer and accounts for approximately 5 to 7% of the total water usage of the city.

2.4.5 Artificial recharge of the Windhoek Aquifer

The Windhoek Aquifer is located in the quartzite formation of the Auas Mountains and can provide approximately 16% of the current water demand (City of Windhoek, 2018). Over-exploitation of the aquifer due to lack of rainfall has led to lower water-table levels in some parts of the aquifer. The CoW has thus implemented Managed Aquifer Recharge (MAR) initiatives. The aquifer recharge project is divided into four phases, with the last phase initially scheduled for completion in 2018. Due to lack of funds, the completion of this scheme could not be realised and progress was reportedly only at 40% by 2017. The project is still ongoing (City of Windhoek, 2019).

According to De Waal (2004, in Van Rensburg, 2006), the artificial aquifer recharge provides the following benefits:

i) Reducing evaporation losses from surface dams by banking water underground during years of surplus runoff

ii) Making use of deep wells (400 to 500m) to store up to 100Mm^3, which can be abstracted during times of shortage

Having large 'banks' of water available at the point of consumption, which makes it possible to supply the peak demand from the aquifer. This in turn means that the bulk water infrastructure from NamWater does not need to be designed for peak demand, only for average demand (Van Rensburg, 2006).

2.4.6 Water Conservation and Water Demand Management

Water Conservation (WC) and Water Demand Management (WDM) are both aimed at the sustainable use of the urban water and thus contribute to IUWM (Armitage *et al.*, 2014). WDM looks at altering the ways in which water is used to ensure more efficient and cost-effective water use. It is defined as: '*Any action or process that promotes the more efficient and sustainable use of water resource*' (Deverill, 2001). WDM can help save money for municipalities by reducing or delaying the need for physical and infrastructural investment. WC, on the other hand, refers to: '*the minimization of water loss, the protection of water resources and the efficient and effective use of water*' (DWAF, 2004). The three main objectives of WDM are:

i) Reducing non-revenue water

ii) Reducing wastage at the point of use

iii) Reducing demand for potable supplies.

WDM has been implemented in Windhoek on an *ad hoc* basis since 1992 (Van Rensburg, 2006). An IUWM policy was developed by the CoW during the first half of 1994 and approved in July of that year. According to Esterhuizen (2004, in Van Rensburg, 2006), the WDM measures taken in Windhoek are centred on policy, legislation and technical issues, but include public education and awareness.

According to information received from the City of Windhoek (2019), since the implementation of the WDM strategy in 1994, Windhoek has seen a drastic reduction in water usage, despite rapid population growth over the years. This is evident from Figure 13 below.

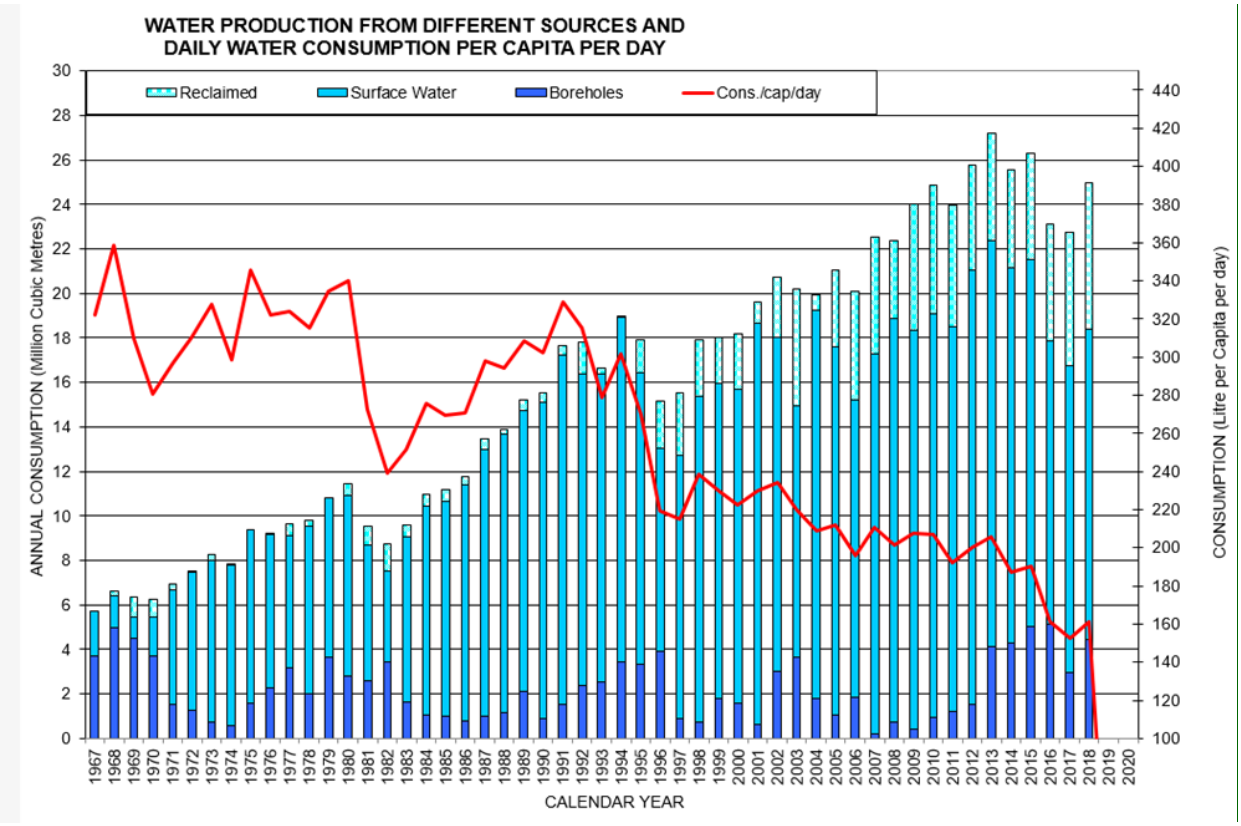

Figure 13: Water production from different sources and daily water consumption per capita per day

Source: City of Windhoek, 2019.

On the other hand, water augmentation measures implemented by the City of Windhoek – such as Managed Aquifer Recharge (MAR), direct waste water reclamation and the dual pipe system – have resulted in reduced production levels from conventional sources such as surface water and ground water.

According to the CoW's Water Management Plan (2019), WDM measures cannot be implementation in isolation. Instead, an integrated approach is required to ensure a successful reduction in water demand. The measures implemented, which will be discussed in the following section, include public awareness, enforcement, monitoring and evaluations, water scarcity tariffs and restrictions.

The residential category in Windhoek takes up 60% of the water usage while 40% constitutes non-residential usage (City of Windhoek, 2019). For this reason, the CoW's WDM strategy puts emphasis on the reduction and restriction of residential water usage as more water can be saved in this category. In 2016, the CoW declared a water crisis and as a result imposed stringent water restrictions. The target for saving water was set at 40% for the residential category, and a 33% water saving was achieved in 2017 (City of Windhoek, 2019). As a result of the savings achieved in 2017, the CoW realised that even more savings can be obtained

by continuously enforcing water restrictions as guided by the water supply situation. Annually, the CoW determines the water demand management category based on the water supply situation as announced by the national water provider, NamWater (CoW Water Management Plan, 2019). As indicated in Figure 14 below, the CoW declared a severe scarcity water situation (category D) for 2019/2020, which required a 15% water saving. In response to the water supply scenario, the CoW then implemented a water demand management action plan.

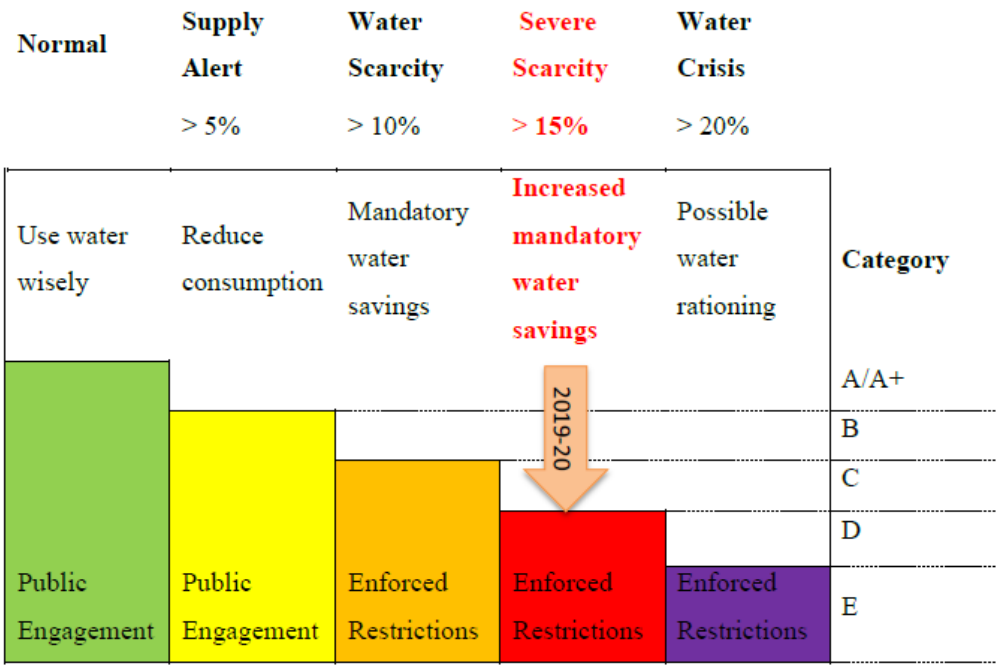

Figure 14: WDM Response Index (WDMRI) in response to available water supply
Source: CoW Water Management Plan, 2019.

2.4.7 Water Demand Management policy and legislation

Water Demand Management was first included in the Namibian Water Policy of 2000 and then later addressed in the Water Resources Management Act, No. 24 of 2004. This was later replaced by the Water Resources Management Act, No.11 of 2013. As discussed earlier, the City of Windhoek has adopted a Water Demand Management Policy in 1994. The WDM strategy is centred on policy, legislation, technical issues and public campaign, none of which should be implemented in isolation, as summarised below.

2.4.7.1 Policy issues

Policies implemented include the 'rising block tariff system' which allows for the incremental cost of water with increased usage. An example of the City of Windhoek's domestic rising block tariff (N$/kl) for the 2017/2018 financial year is indicated in Table 2 below:

Table 2: Domestic block tariffs for the 2017/2018 financial year

Source: City of Windhoek, 2019.

Domestic Block tarrifs	
Category	**Tarrif per Kilolitre**
0 - 0.200kl per day (0 - 6kl p.m.)	19.25
0.201 - 1.00kl per day (6 - 30kl p.m.)	29.91
1.001kl - 1.50kl per day (30 - 45kl p.m.)	55.17
more than 1.50kl per day (> 45kl p.m.)	127.13

In a study carried out by Van der Merwe, it was revealed that 'water is constantly overused because it constantly is underpriced'. This did not only apply to Windhoek, but to the entire Namibia as well. As such, an efficient water tariff policy system is highly instrumental for the successful implementation of the WDM policy (Van der Merwe, undated).

2.4.7.2 Legislation

New water supply regulations were developed in 1996 to address water conservation in Windhoek. These regulations forbid the watering of gardens at certain times during summer and during periods of high evaporation. The regulations also promote the use of water through efficient fittings in buildings (Van Rensburg, 2006). Pamphlets explaining the CoW legislation with regard to WDM are attached as Appendix C and Appendix D (City of Windhoek, 2018).

2.4.7.3 Public awareness

Public awareness of water conservation was created through customer advice, participation and the distribution of pamphlets on the efficient use of water. An example of the CoW public awareness information pamphlet is attached as Appendix E (City of Windhoek, 2018).

2.4.7.4 Technical measures

The technical measures implemented included:

- Reducing non-revenue water through improved operation and maintenance. Non-revenue water in the Namibian context is defined as water that was produced but is lost through leakages, etc. before it reaches the customer. See Appendix D (City of Windhoek, 2018). According to the City of Windhoek's WDM programme (2018), un-accounted for water leads to lost revenue – hence the term non-revenue water. The CoW has put the following measures in place to minimise non-revenue water: zonal meters, leak control valves and pipe leak detection.
- Water audits on large commercial, industrial and government properties are carried out on a continuous basis through the CoW Marshal Programme (City of Windhoek, 2018).
- Artificial recharge of the Windhoek Aquifer allows for the conservation of water.

- Rain water harvesting is recommended by the CoW.

Despite efforts made by the CoW towards WDM and IUWM, there is still room for improvement towards a holistic way of water management. However, there is a lack of effective water management in most countries caused by the fragmented management of the urban water cycle by responsible parties, with stormwater often separately managed from water supply and wastewater treatment. Windhoek is no exception.

2.5 Concluding remarks

This chapter reviewed literature pertaining to Water Sensitive Urban Design (WSUD). Various WSUD options were listed. The chapter further presented the concept of Water Sensitive Cities (WSC) and the South African alternative of Water Sensitive Settlements (WSS). Two transition frameworks were discussed. In addition, the barriers, challenges and drivers of WSUD implementation were briefly discussed. The chapter ended with a case study of the water situation in Windhoek. The next chapter will present the research methodology for this study.

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the research method followed to execute the research assignment. It starts with the research design, including the approach undertaken during the data gathering process. It ends by looking at aspects of ethical issues considered in this study. Qualitative methods of research were used which involved conducting a survey and interviews with City of Windhoek officials to review and analyse the existing Water Sensitive Urban Design (WSUD) within the city. The data used in this research was collected in two different ways: a survey questionnaire was sent to the targeted group that deals with WSUD within the City of Windhoek, and structured interviews were conducted with selected representatives of the sample to validate the findings of the study. Data collected from the interviews was tape-recorded with the permission of the participants and transcribed into electronic format.

3.2 Research design

According to Kurebwa (2013), research design provides a structure to logically investigate a specific research problem. The structure shall provide sufficient evidence and findings to achieve the specific research aims and objectives.

Although research design might be unique to a specific research problem, it should use one of the following five research design methods as described by Perri 6 and Bellamy (2012):

i) An experimental design method that focuses on laboratory and field experiments to gather data;

ii) A cross-sectional design method that uses methods such as participant observations and journals;

iii) A longitudinal design method used to map the changes experienced by an organisation;

iv) A case study design method that focuses on a particular aspect which is then analysed in depth; or

v) A comparative design method that focuses on comparing two or more cases in order to draw comparisons.

This research made use of a cross-sectional design method in which participants' responses were used to obtain qualitative data. The participants' responses were obtained via an online questionnaire sent to employees from the City of Windhoek, asking them to review WSUD within the city. The employees were selected as the only participants to provide their knowledge, experience and exposure to WSUD practice in Windhoek. To validate observations from the participants, interviews with selected participants were conducted to obtain further clarification and confirmation from key people.

3.2.1 Qualitative research

According to Stangor (2011), qualitative research is defined as descriptive research that primarily focuses on observing and describing events as they occur, with the goal of capturing all of the richness of the everyday behaviour. The researcher thus acts as the instrument for

data collection and ultimately analyses the data. Usually the researcher needs to physically visit the people, interview setting or site to observe and record behaviour.

The rationale of using a qualitative method in this study was to make sure that an appropriate source of data is used to meet the research objectives. The qualitative method thus assisted in obtaining the views of CoW officials as insiders on WSUD implementation in the city, allowing the researcher to corroborate or negate published data on WSUD implementation in the city. This method further presented an opportunity for the CoW officials to gauge their views and provide recommendations on the future of WSUD within the CoW. In addition to qualitative methods used for data collection, the literature was also used as secondary data to augment data collected via qualitative methods.

The objective of qualitative research is to find answers to research questions from participants by creating and interpreting their social experience on the subject matter (Stangor, 2011). To meet the above objectives, the research focused on the context, perspectives and experience of the participants in order to describe and understand the implementation of WSUD within the CoW. The CoW employees involved in water, urban infrastructure design and planning were therefore selected as participants to share their knowledge based on their exposure and experiences.

3.2.2 Advantages and disadvantages of qualitative research methods

This section aims to reflect on the advantages and disadvantages of using qualitative research methods in this study. This is crucial in highlighting the strengths and weakness from the findings of this study, as will be discussed in subsequent chapters.

3.2.2.1 Advantages

Putney and Green (1999) identified the following advantages of qualitative research methods:

i) It expands the range of knowledge and understanding beyond the researchers themselves.

ii) It provides ways to transcribe and analyse the discursive construction of everyday events, examine the nature of the subject matter, and explore the historical nature of life within a social group or setting.

iii) It provides insight into the participants' way of life so that the researcher can behave appropriately without offending the participants.

iv) It provides information about why and how miscommunication occurs between people, especially when people are members of different groups.

v) The approaches and theories that guide qualitative researchers raise awareness of different voices; and awareness of the need to consider whose voice will be represented, how, in what ways, and for what purposes.

3.2.2.2 Disadvantages

Despite the advantages of qualitative research, Putney and Green (1999) also identified the following shortcomings of a qualitative research method:

i) The smaller sample cannot be generalised for a large population.

ii) It can be costly and time-consuming to collect data from a large sample.

iii) The quality of the research depends heavily on the researcher's skills.

iv) The contribution to the existing body of knowledge is more difficult to prove than with quantitative research.

v) Researchers have their own experiences and views on the subject matter, making it difficult to remain independent when carrying out inductive reasoning processes.

3.3 Research sampling

Neuman (2011:240) stated that a sample is '*a smaller set of cases a researcher selects from a larger pool and generalises to the population*'. The sampling process aims to establish a representative sample of the population to enable generalisation of the findings to the entire population. For the sample to be a true representative of the population, Martin, Kevin and Desmond (2006: 49) stipulated that, "*the researcher must ensure that the sample is large enough as a very small random sampling may be quite unrepresentative, and the same is true for a large non-random sample*".

The CoW consists of nine departments with a staff complement of about 2700 in total (excluding the Councillors who are not full-time employees). For the sake of this study, six managers and 29 specialists from the three departments within the CoW that deal with urban infrastructure design and planning were approached for the data collection. The three departments were Infrastructure, Water & Technical Services; Urban Planning; and Economic Development. The specialists comprised engineers, town planners, environmental managers and architects. They were selected because they are key to the implementation of WSUD.

The questionnaire (Appendix A) was uploaded to an online survey platform (Survey Monkey Inc, 2018) and was distributed to the 35 targeted interviewees via email as City of Windhoek's departments are located in different areas of the city. This approach was followed as it allowed for a time-efficient and convenient way of collecting data.

In an attempt to increase the response rate and to further validate the outcome of the survey, one manager and one specialist were selected through purposive sampling for interviews, as recommended by Saunders, Lewis and Thornhill (2009: 237). These selected interviewees were chosen based on their knowledge, skills and expertise in WSUD within the city. Hence, they were considered as suitable to provide reliable information in order to answer the research questions.

3.4 Data collection

Data collection is of critical importance in the research process. According to Saunders and Lewis (2012: 219), research design connects the research questions with data since data is

collected and analysed from a sample using tools and procedures. This research required specific information in order to accurately respond to the research questions. As with most qualitative research, the research information covered four general areas such as contextual, perceptual, demographic and theoretical information in evaluating and assessing the research participants and interviewees with regard to their understanding, experience and views on the concept of WSUD within the City of Windhoek. Data from all the four areas was obtained via the following data collection methods used in this research:

3.4.1 Survey questions

This study used a self-administered questionnaire to collect qualitative data. According to Martin *et al*. (2006: 489), a questionnaire is a '*group of written questions used to gather information from respondents*'. The questionnaire should be designed to help answer research questions and reach stated research objectives. The questions used in the questionnaire were conceptualised by the researcher to achieve the research objectives and were also guided by the existing body of literature pertaining to WSUD, as explained in Chapter 2. Purposive sampling interviews assisted the researcher to gauge the understanding of the WSUD concept within the city and to refine the research questions further. The questionnaire (Appendix A) contained 22 questions and was structured into four parts, as described below.

1) **Part 1: Demographic information**
   This part covered Questions 1 to 5, and was aimed at providing demographic and background information on the participants. This information pertained to age, job title, division, qualifications and experience within the city. This information is crucial for segmentation of the survey outcomes.

2) **Part 2: Review and knowledge of the WSUD concept**
   This part covered Questions 6 to 12, and was aimed at gauging the participants' understanding and experience of WSUD within the City of Windhoek.

3) **Part 3: City of Windhoek management commitments to WSUD via policies and regulations**
   This part covered Questions 13 to 16, and was aimed at assessing and reviewing the City of Windhoek's commitment to the implementation of WSUD via Council policies, regulations, standards and guidelines.

4) **Gap analysis of WSUD**
   This part covered Questions 17 to 22, and was aimed at identifying existing gaps and opportunities of WSUD within the City of Windhoek through open-ended questions to the participants in order to obtain their views on how best the City of Windhoek can address gaps, if any.

According to De Vos, Strydom, Fouché and Delport (2011), the questionnaire must conform to a set of principles and rules to improve the response rate from participants. The following principles, as recommended by De Vos *et al.* (2011), were adhered to in setting up this questionnaire:

i) Questions must be brief and clear;

ii) Questions and response alternatives must be clear and not biased;

iii) Each question must have one main idea;

iv) Each question must be relevant to the research purpose;

v) The questions must be sequenced from non-threatening to sensitive.

As recommended by Saunders and Lewis (2012), the questionnaire used a combination of open-ended and closed-ended questions to obtain more uniform responses from the participants. Rules were built into the survey to ensure that the participants answered all questions before submitting their surveys. This means that options such as *Not sure* and *No comment* were included. Also, the participants were reminded of incomplete questions before moving to the next questions. The participants were not allowed to submit incomplete questionnaires.

3.4.2 Personal interview questions

The second strategy of data collection was the interviews, which were used to collect detailed qualitative data. Interviews, using open-ended questions, were conducted with the selected managers and specialists at the municipality of Windhoek. Each interview lasted 20 to 30 minutes. The interview sessions were recorded with the permission of the participants. The interviews tested the same areas as the questionnaire, with the aim of validating the questionnaire outcomes by asking follow-up questions during the face-to-face sessions.

3.5 Data analysis

Data collected through the questionnaires was analysed using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel software to present information in the form of tables, graphs and figures. The data collected from the interview sessions was transcribed and analysed manually using content analysis techniques.

3.6 Validity and dependability

De Vos *et al*. (2011) defined data validity as the extent to which the research findings accurately represent reality. To ensure the credibility of the data collected, the same set of questions was presented to all the participants. A pilot study to validate the applicability of the questions was initially carried out with three selected participants to ensure that the questions were relevant and easily understood by the participants. Experience from this helped to guide the wording of certain questions and reduced them to a manageable number without losing the focus of the subject. These questions were then used for the survey.

To ensure the accuracy and reliability of data, the researcher recorded all the interviews with a voice recorder to ensure no data was lost.

3.7 Ethical considerations

Ethical considerations are important in academic research. De Vos *et al.* (2011) defined ethics as '*a set of moral principles that guide the behaviour of people who are involved in the research study processes*'. They stressed that '*research should be based on mutual trust, acceptance, cooperation, promises and well-accepted conventions and expectations between all parties*

involved in the research project' (2011: 113). The researcher considered ethical issues during the entire research process. The following potential ethical considerations, as identified by De Vos *et al*. (2011), were adhered to in this research:

i) The avoidance of harm;

ii) Voluntary participation and the ability of the respondents to withdraw their participation. (This was provided for in the survey as participation was voluntary and participants could choose not to complete the survey.);

iii) Informed consent;

iv) The survey questions were very clear to avoid deception of subjects and respondents;

v) The privacy, anonymity and confidentiality of respondents were respected by ensuring that the respondents did not have to complete personal information on the survey; and

Permission was obtained from the relevant authority (CoW) to conduct the research. The letter allowing the researcher to conduct the study was issued by the CoW Human Resources Department (Appendix B). The same letter was sent with a survey invitation to all participants to confirm that the study was authorised by the City of Windhoek.

3.8 Concluding remarks

This chapter presented the research methodology that was selected for this study. Relevant research methodology aspects such as research design, data collection and data analysis were discussed. The chapter also looked at how validity and reliability were achieved in the research and the measures undertaken to deal with ethical issues. The next chapter will present the results of collected data and analysis.

4. DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter presents the collected data and analyses both the survey and interview results as guided by the research objectives.

4.2 Survey data validation

The questionnaire was designed to address the research objectives as discussed in Chapter 1. Of the 35 professionals invited to participate in the survey, 25 responded representing a 72% response rate. Fortunately, all of them completed the survey, which represents a 100% active response rate, as indicated in Table 3. The remaining 10 participants, representing 28% of the targeted population, did not respond despite several follow-up reminders and pleas to complete the survey. They were then ignored, which supported the researcher's ethical position of working with willing participants. Nevertheless, the relatively good participation and active response rate validated and demonstrated the integrity of the research data, as required by De Vos et al. (2011).

Table 3: Survey response rate

Participant response to survey questionnaire	Frequency	Percentage
Completed	25	71.4 %
No response	10	28.6 %
Total	**35**	**100%**

4.3 The respondents' demographic data presentation and analysis

The questionnaires and interview sessions started off with the biographical information of the respondents, as reflected in Appendix A. The biographical information captured for this study included age, occupation, department, experience and education level.

4.3.1 Participants' age group

As indicated in Figure 15, most of the respondents were between the age of 30 and 39, which represented 56% of the sample.

The youngest age group (21-29 years) was represented by only one respondent, which is 4%, while the 40-49 years age group was represented by 24%. On the other hand, the older age group (between 50-59 years) was only represented by 16% of the sample. Age distribution analysis was vital to this study as it helped the researcher to establish an understanding of the WSUD concept and gaps within the CoW among various age groups, which will assist in determining the future of WSUD within the CoW. Most of the participants were young people who are considered as the future leaders and who are likely to have the most impact on the implementation of WSUD within the CoW as the older generation are approaching retirement.

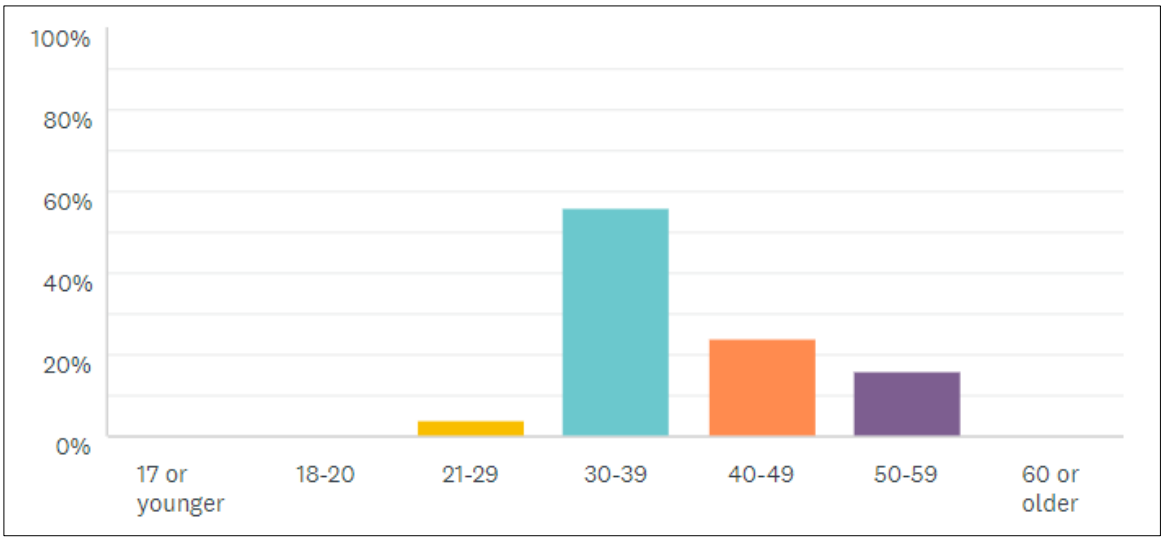

Figure 15: The participants' age distribution

4.3.2 Participants' job titles

The largest category of respondents (Table 4) were engineers or technicians, accounting for (28%) of the respondents. This category was followed by town planners and section heads who accounted for 24% of the respondents. These target groups were vital for this study as they are responsible for the planning and design of urban infrastructure within the CoW.

Table 4: Job titles of the participants

Participant's job title	Frequency	Percentage
Chief Engineer or Architecture/Divisional Manager	3	12%
Town/Urban Planner	6	24%
Environmentalist/Environmental Officer	3	12%
Section Engineer/Section Head	6	24%
Engineer/Technician	7	28%
TOTAL	**25**	**100%**

The divisional managers and environmentalists each accounted for 12% of the participants. Despite the perceived low response from this group, this response overall represents more than 50% of the targeted category due to their small size. As a result, the views and opinions from these categories are well represented. Information pertaining to the participants' job titles is crucial to assess gaps of WSUD within the CoW by ensuring that all expert areas are included and participate in the study. A gap here would represent a lack of social experts/scientists who could facilitate engagements with water users.

4.3.3 Participants' departments

As reflected in Figure 16, most of the respondents were from the Infrastructure, Water & Technical Services Department, which represents 60% of the sample selected from the three relevant departments that deal directly with WSUD within the City. This is the department that generally deals with water and wastewater.

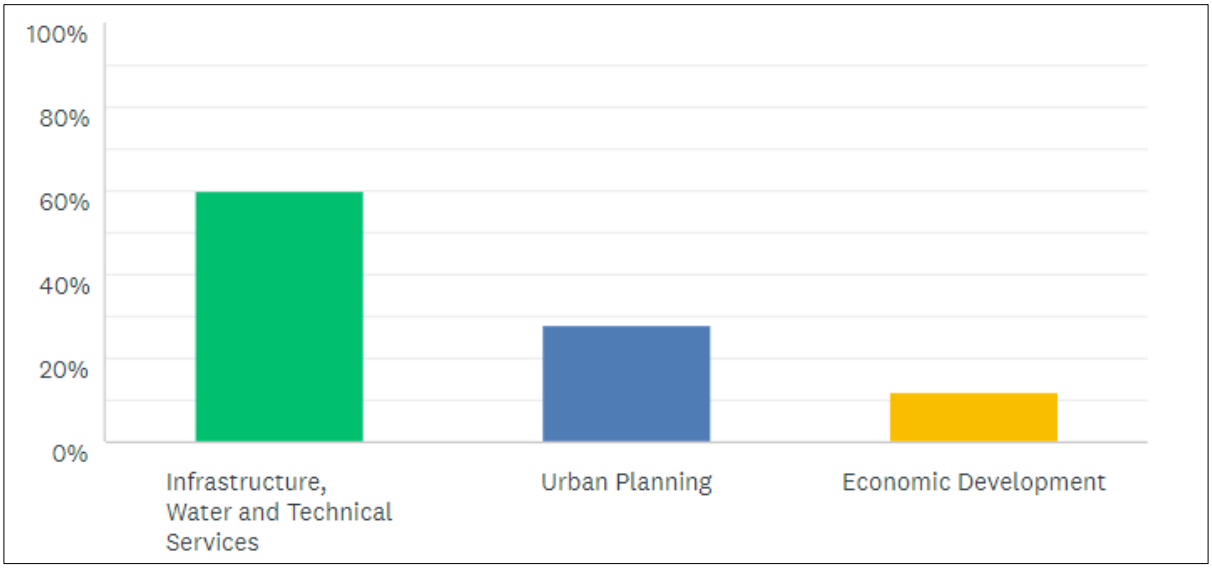

Figure 16: The participants' department distribution

The Urban Planning Department accounted for 28% of the respondents. This target group was crucial as they were involved in the planning of urban infrastructure within the CoW. The remaining 12% of the respondents were from the Economic Development Department due to a small number of environmental managers in the department. Implementation of the WSUD concept requires coordination among various departments and disciplines; hence it was crucial to engage with all the relevant departments in the study.

4.3.4 Participants' years of experience

To improve the reliability of the responses, respondents were asked to indicate how long they have been in the service of the CoW. The researcher also took cognition of the fact that the people in middle management could have prior experience before joining the municipality. However, those who have been with the municipality longer are likely to have a better understanding of the WSUD implementation within the organisation, which should reflect in their responses.

Figure 17 indicates that most of the respondents (60%) had worked for the City of Windhoek for more than five years. Only one respondent had been with the council for a year or less.

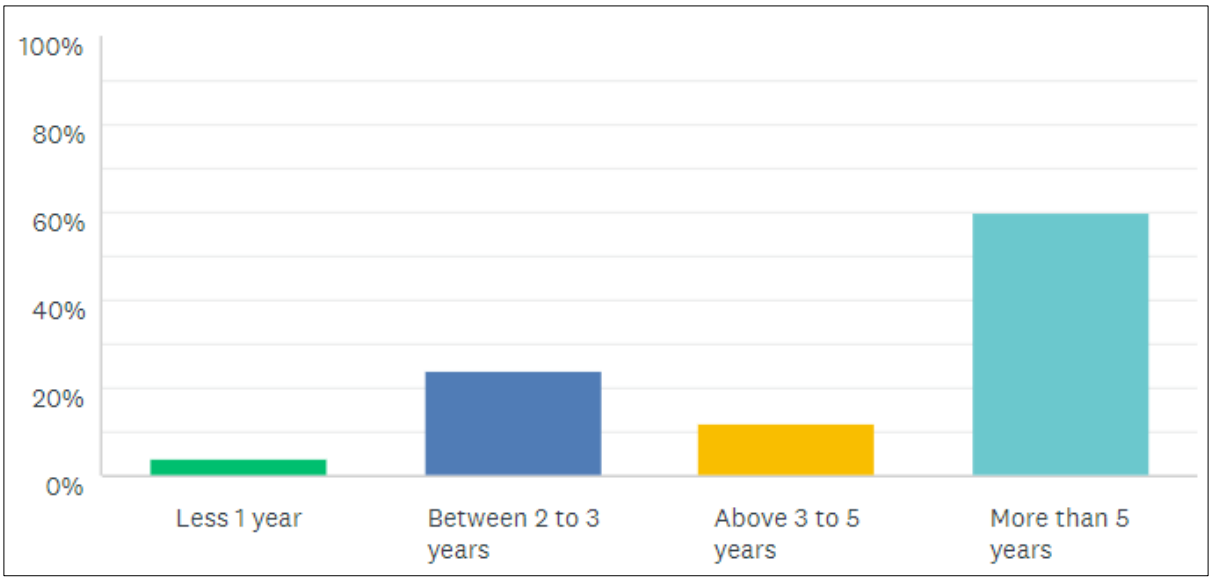

Figure 17: The participants' experience distribution

It is quite evident from the respondents' profiles, presented in Figure 17 above, that most of the respondents had relevant working knowledge and experience in the City of Windhoek to provide reliable responses and useful opinions regarding WSUD in the city as covered in the questionnaire.

4.3.5 Participants' level of qualification

According to Dewah (2012), respondents with higher levels of educational qualifications are generally considered more competent and thus more likely to appreciate studies that are undertaken in their organisation. The researcher was confident that the chosen sample group was competent enough to fully value, comprehend and appreciate the questionnaire or interview questions to provide reliable responses.

Figure 18 below reflects that most of the respondents had a Master's degree (56%), while 12% had a Bachelor of Science degree, 24% had a Bachelor of Technology degree and 8% had diplomas.

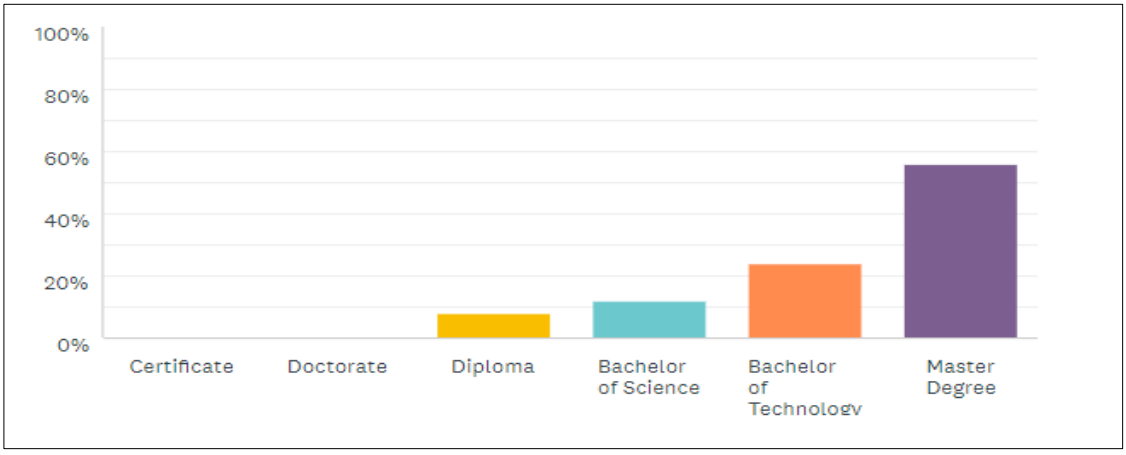

Figure 18: The participants' qualification distribution

The above qualification distribution of the respondents provided confidence that the responses provided were competent and reliable.

4.4 The respondents' views and knowledge of the WSUD concept

4.4.1 Knowledge and understanding of the WSUD concept

The respondents were asked to indicate their knowledge and understanding of WSUD concept within the CoW (Table 5).

Table 5: The participants' knowledge of WSUD

Participant response to knowledge of WSUD concept	Frequency	Percentage
Yes	12	48%
No	2	8%
Not sure	11	44%
Total	**35**	**100%**

As reflected in Table 5, almost one-half (48%) of respondents claimed to have knowledge of the WSUD concept. About 44% of the respondents were neutral about the concept; this may be due to this question being deliberately set earlier in the questionnaire to immediately gauge the respondents' understanding of the concept. Only 8% of respondents indicated not having knowledge of the WSUD concept.

4.4.2 Coordination of WSUD activities within the city

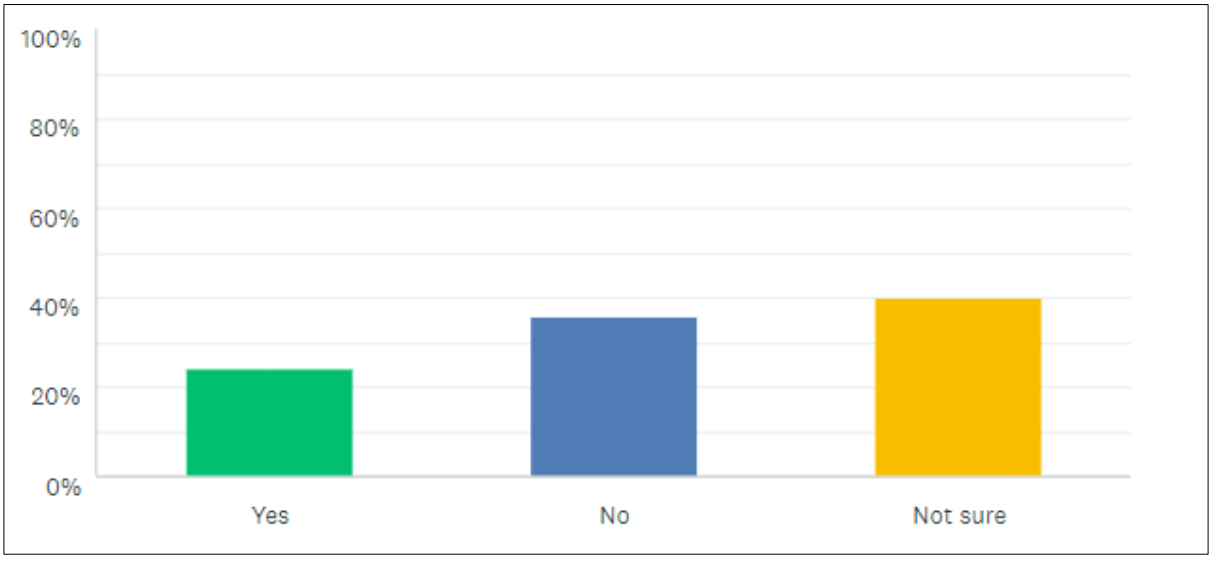

Figure 19: The participants' views on WSUD activity coordination

According to Armitage *et al*. (2014), a fragmented and silo approach towards the management of water systems was identified as one of the impediments to implementing WSUD within South African municipalities. The respondents of the survey were asked to indicate whether

WSUD practices are well coordinated within the CoW. This question was aimed at identifying gaps pertaining to WSUD practices within the CoW. Their responses are recorded in Figure 19.

As indicated in Figure 19, 36% of the respondents believed that there was no coordination among the relevant parties within the CoW as far as WSUD is concerned. Furthermore, 40% of the respondents were not sure if such coordination existed. Only a mere 24% of respondents believed that the WSUD practices were coordinated. It is evident that coordination is a challenge when it comes to planning and design of urban infrastructure within the CoW. This could be due to 'silo management', alluded to in the literature as a consequence of water and waste water being managed separately from stormwater within the CoW.

4.4.3 Importance of WSUD to the city

According to Taylor (2008), WSUD champions within an organisation are vital to drive the implementation of WSUD. The respondents in this research were asked to indicate the importance of WSUD to the CoW and to assess whether the CoW advocated for WSUD. This assessment will help with recommendations on how to fast-track WSUD implementation within the CoW.

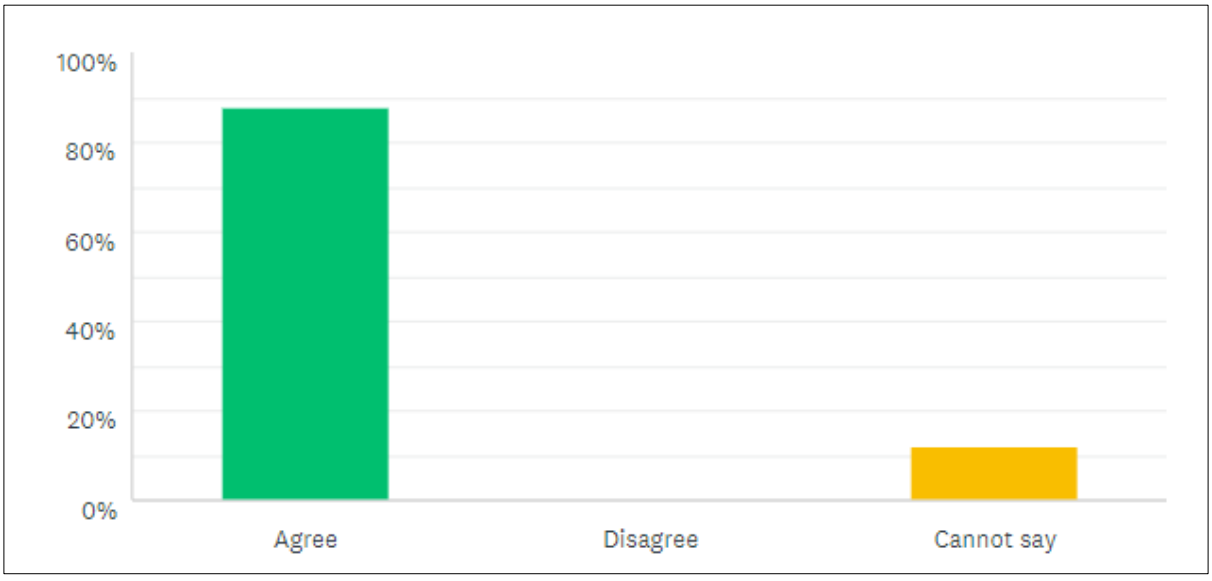

Figure 20: The participants' views on the importance of WSUD in the city

As indicated in Figure 20, an overwhelming majority (88%) of the respondents believed that WSUD is critical to the CoW. None of the respondents disagreed with the importance of WSUD, while only 12% of the respondents were unsure. Based on this, there is little doubt that the people most likely to be responsible for implementing WSUD within the City of Windhoek value the importance of the WSUD practices.

4.4.4 WSUD Practice within the city at building and household levels

Myers *et al*. (2014) described various WSUD options that can be implemented at various levels. The respondents were asked to indicate if they were aware of the existing WSUD

practices within the CoW at the household level. The aim of this question was to determine whether WSUD is supported within the CoW by providing a review of existing practices. The participants' responses are indicated in Figure 21.

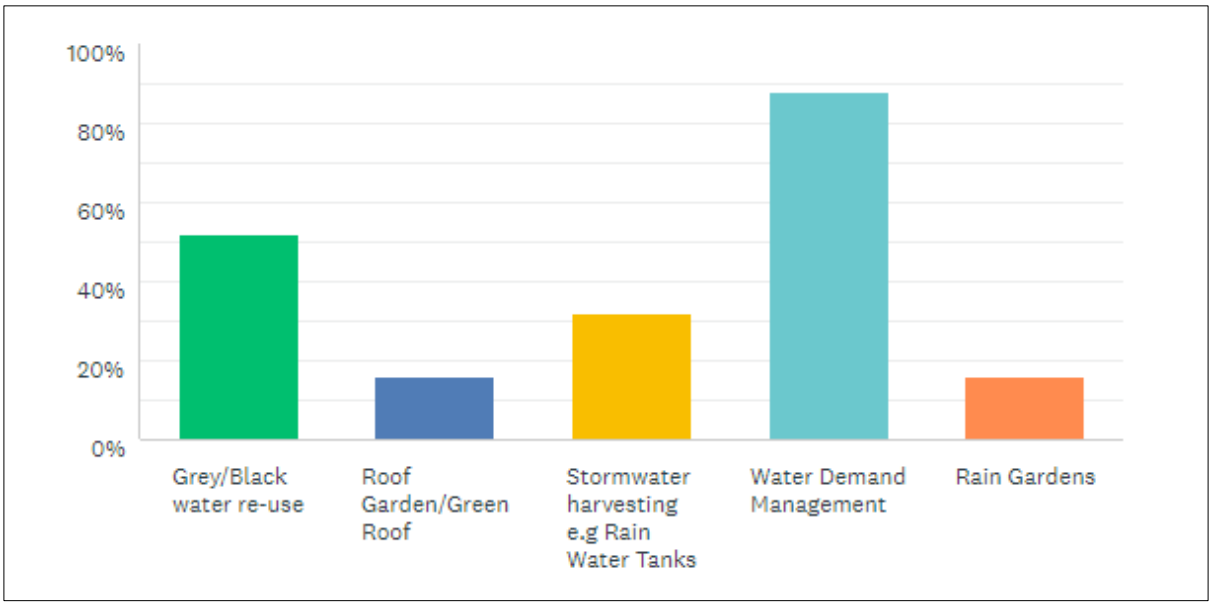

Figure 21: Existing WSUD in the city at building and household levels

As reflected in the figure above, the majority (88%) of respondents indicated Water Demand Management (WDM) as the most recognised WSUD practice that occurs at household level. This is supported by the fact that this is one of the key initiatives within the City of Windhoek's Integrated Urban Water Management Plan.

Greywater re-use accounted for the second highest practice at 52%. This score is higher than expected, but validation with face-to-face interviews concluded that respondents might have confused it with reclaimed waste water from the Goreangab Water Reclamation Plant (GWRP) that accounts for 30% of total portable water use in Windhoek households.

Rainwater harvesting accounted for 32% of the respondents. Due to the water scarcity in Windhoek, some residents practiced rainwater harvesting to ensure sufficient water supply, especially during periods of water restrictions. The City of Windhoek's guidelines recommend rainwater harvesting for non-potable use such as swimming pools, car wash and fish ponds.

On the other hand, rain gardens and green roofs both received the lowest score (16%) from the respondents. This is expected due to Windhoek's arid nature, implying that the climatic conditions are not favourable for these initiatives. However, a few private companies such as Old Mutual and FNB headquarters have implemented green roofs to acquire green building status as part of their corporate image, which explains the 16% score.

4.4.5 WSUD practices at street and neighbourhood levels

The implementation of WSUD options at street level is another option for organisations, as described by Myers *et al*. (2014). The respondents were asked to indicate whether they were

aware of the listed WSUD practices within the CoW at street and neighbourhood levels. The aim of this question was to determine whether WSUD is supported within the CoW by providing a review of existing practices. The participants responded as indicated in Figure 22.

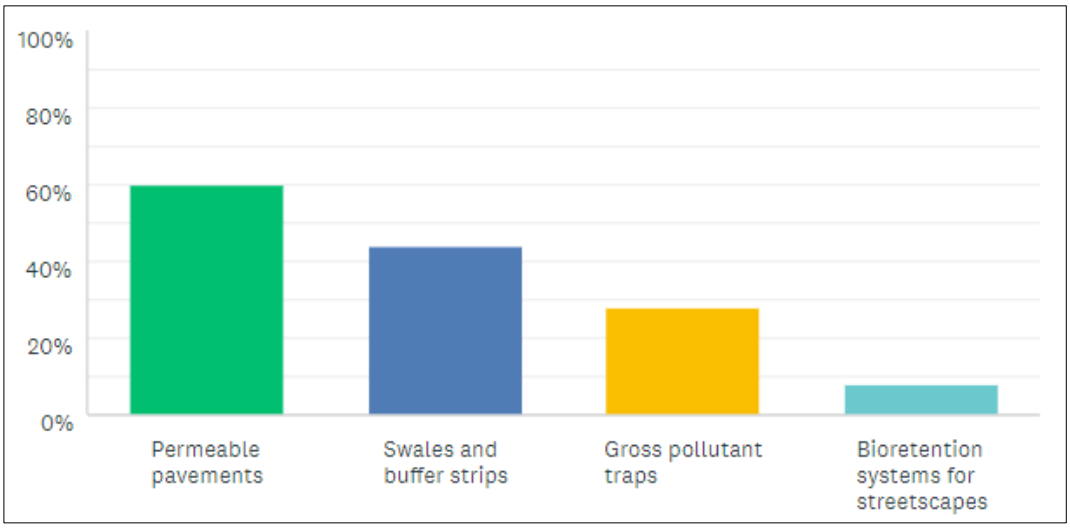

Figure 22: Existing WSUD in the city at street and neighbourhood levels

The majority (66%) of the respondents indicated permeable pavements as the dominant WSUD practice implemented at neighbourhood level. Swales and buffer strips accounted for the second highest identified practice at 44% of the respondents. Gross pollutants traps accounted for 28% of respondents while bio-retention systems scored a mere 8%.

4.4.6 WSUD practices at precinct level

Myers *et al*. (2014) described various WSUD options that can be implemented at various levels. The respondents were asked to indicate all existing WSUD practices within the CoW at precinct level. The aim of this question was to determine whether WSUD is supported within the CoW by providing a review of existing practices. The participants responded as indicated in Figure 23.

As reflected in Figure 23, the majority (96%) of the respondents indicated wastewater reuse as an example of WSUD implemented at precinct level. This can be attributed to the fact that Windhoek has been re-cycling waste water for almost 50 years now. Retention ponds accounted for the second highest mentioned practice at 28%. Constructed wetlands only scored 16% from the respondents.

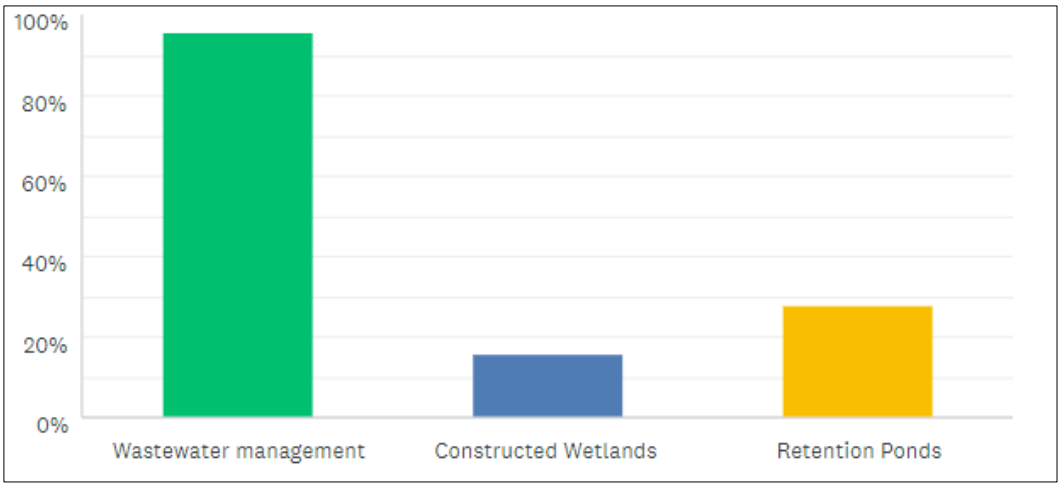

Figure 23: Existing WSUD in the city at precinct level

4.4.7 WSUD responsibility within the City of Windhoek

Various researchers have shown that WSUD is imperative to urban environments (Armitage *et al*., 2014; Lottering, 2011; Morgan *et al*., 2013). Parties responsible for the planning and design of urban infrastructure are encouraged to give prominence to water in the planning and designing of urban infrastructure. It is impossible to achieve this objective with a fragmented approach towards urban infrastructure planning, management and design within any organisation. The respondents were asked to indicate which of the three selected departments within the City of Windhoek were responsible for the implementation of WSUD. By assessing the understanding, roles and responsibilities with regard to WSUD in each department, this question was aimed at identifying gaps and barriers pertaining to WSUD implementation within the City of Windhoek. The participants' responses to WSUD responsibility within the city are indicated in Figure 24.

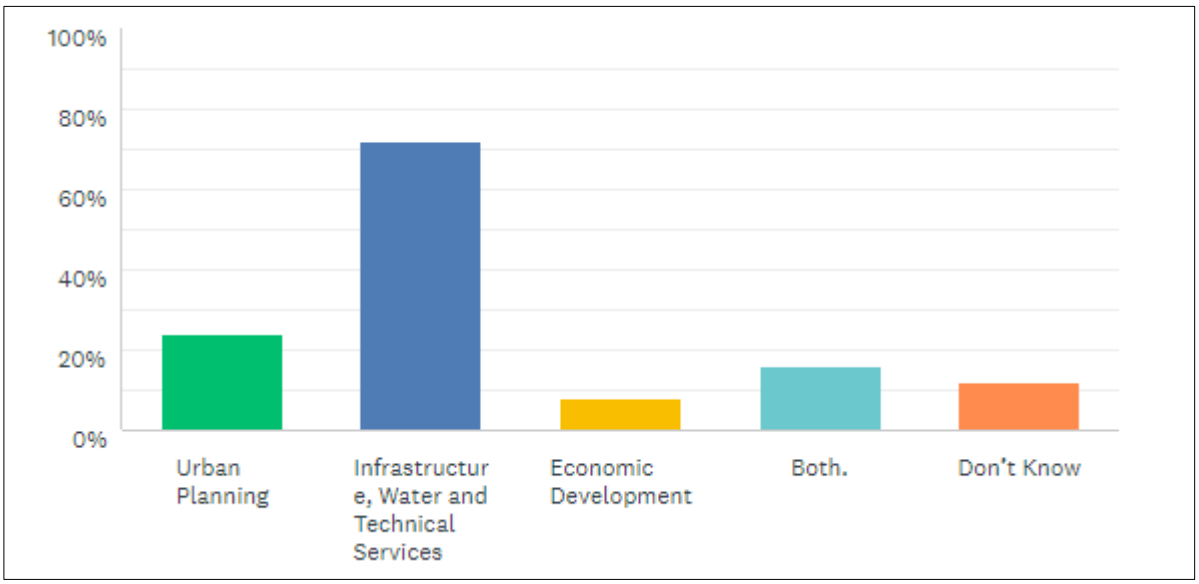

Figure 24: WSUD responsible department in the City of Windhoek

It is evident from Figure 24 that the majority of respondents (72%) believed that WSUD was the responsibility of the Infrastructure, Water & Technical Services Department. However, 24% of the respondents considered the Department of Urban Planning while only 8% believed that it was the responsibility of Economic Development. Interestingly, only 16% of the respondents considered that WSUD was the joint responsibility of the three relevant departments, while 12% of the respondents were not sure where the responsibility resided. Based on the above responses, there was a general understanding that the Infrastructure, Water & Technical Services Department should be responsible for WSUD. The responses to this question imply a 'silo' management approach, which is problematic since it is almost impossible to achieve successful implementation of WSUD through a fragmented approach. It is important to note that WSUD forms part of the IUWM umbrella and requires coordination from various disciplines such as town planning, engineering and architecture.

4.5 The respondents' views on City of Windhoek's management commitment to WSUD

4.5.1 Management commitment to WSUD

Brown (2005) emphasised that low uptake and erratic implementation of WSUD may often be attributed to the unwillingness of management who are the policy makers and who are sometimes stuck in traditional water management practices. The survey looked at the participants' views on the CoW's political and senior administrative management staff's commitment to WSUD implementation within the city. The answers to this question assisted in identifying potential barriers or factors that either impede or contribute to the implementation of WSUD within the CoW. Figure 25 indicates the respondents' views on the CoW's commitment to WSUD implementation.

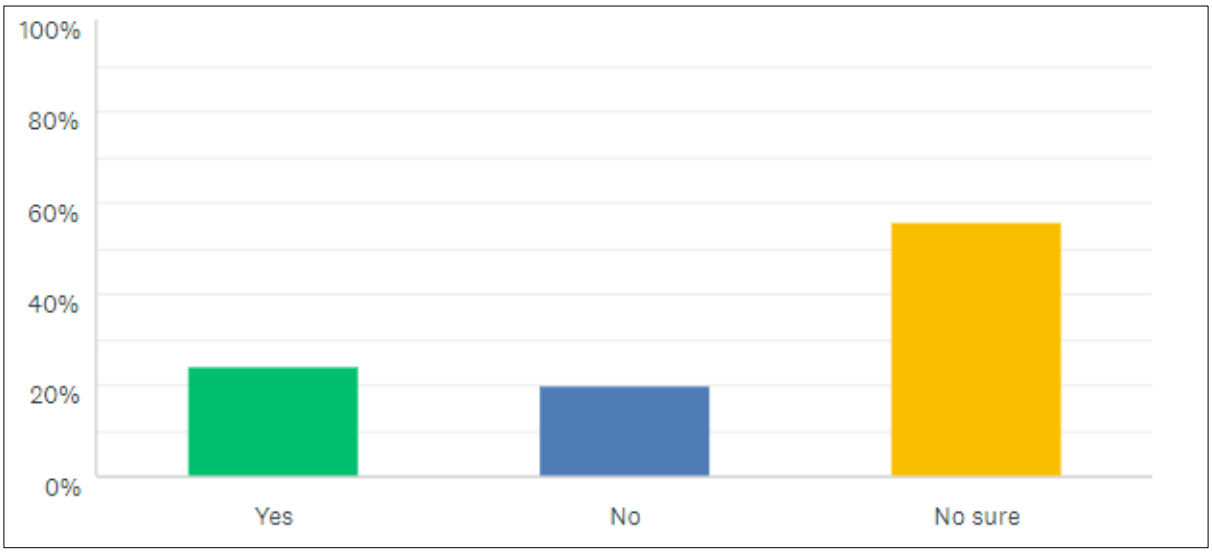

Figure 25: The participants' views on management commitment to WSUD

As reflected in Figure 25, there are uncertainties among the participants whether the CoW's management is fully committed to WSUD implementation. This is confirmed by the fact that 56% of the respondents were not sure of management commitment to WSUD, whereas 20%

indicated that the CoW management is not committed. Only 24% of respondents agreed that there is management commitment toward WSUD implementation within the City of Windhoek.

4.5.2 Assessment of existing WSUD management instruments

The literature review revealed that good penetration of WSUD practices are mainly driven by legislation in terms of policies, regulations and standards. The respondents were asked to indicate all the legal instruments aimed at promoting and driving WSUD implementation that currently existed within the City of Windhoek. This question was aimed at determining whether the City of Windhoek has the legal frameworks to promote and enforce WSUD. Figure 26 indicates the respondents' responses to all the existing WSUD legal instruments in the City of Windhoek.

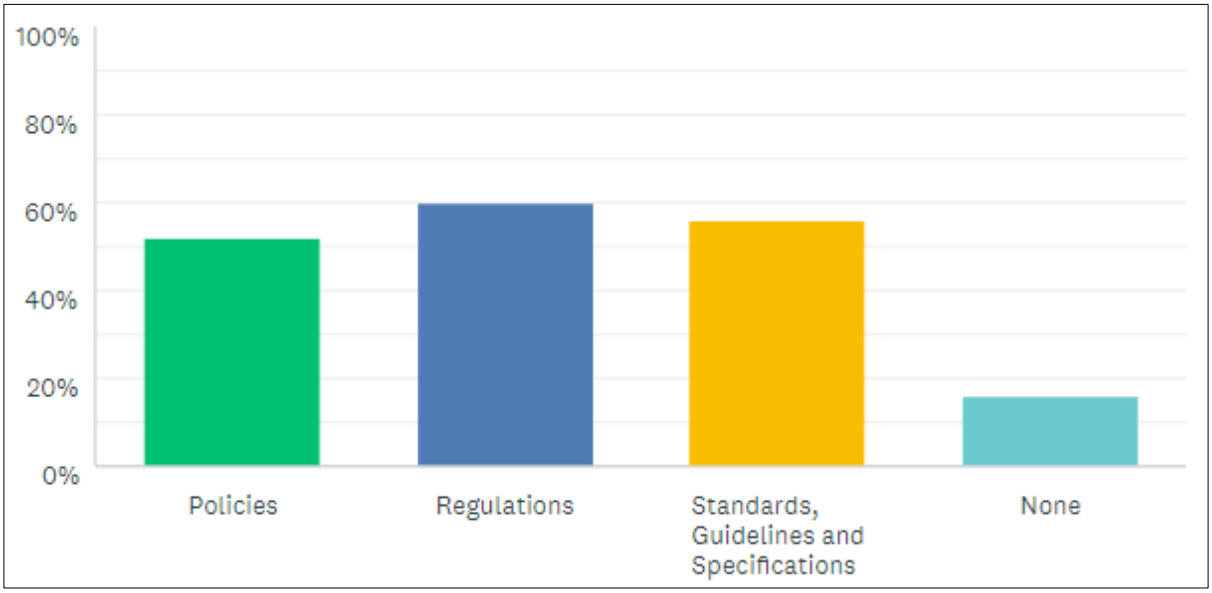

Figure 26: The participants' views on existing WSUD legal instruments in the City

As reflected in Figure 26, the majority (60%) of the respondents indicated regulations as the main legal instrument that advocated for WSUD activities in the CoW. Standards, guidelines and specifications accounted for the second highest WSUD legal instrument – receiving a 56% positive response. On the other hand, 52% of the respondents indicated that WSUD policies existed within the city. The remaining 16% of the respondents indicated that there was a lack of WSUD management instruments promoting WSUD in the CoW. An analysis of this question's responses reflects a present legal framework that advocates for WSUD within the CoW. However, based on further analysis and the outcome of personal interviews, it emerged that there were no specific policies, regulations and standards for WSUD within the CoW. The policies that existed within the CoW focused on WDM and water reclamation, which are all aimed at achieving IUWM. In most cases, the WSUD concept is addressed through the WDM policy.

4.5.3 Validation of existing WSUD specifications and guidelines

This question was intentionally included in the survey to ensure that the respondents did not confuse general CoW legal instruments with specific WSUD legal instruments. The respondents were thus asked to confirm whether there are documented standards, specifications and guidelines within the City of Windhoek pertaining to WSUD. Figure 27 indicates the views of the respondents pertaining to documented WSUD specifications, standards and guidelines in the City of Windhoek.

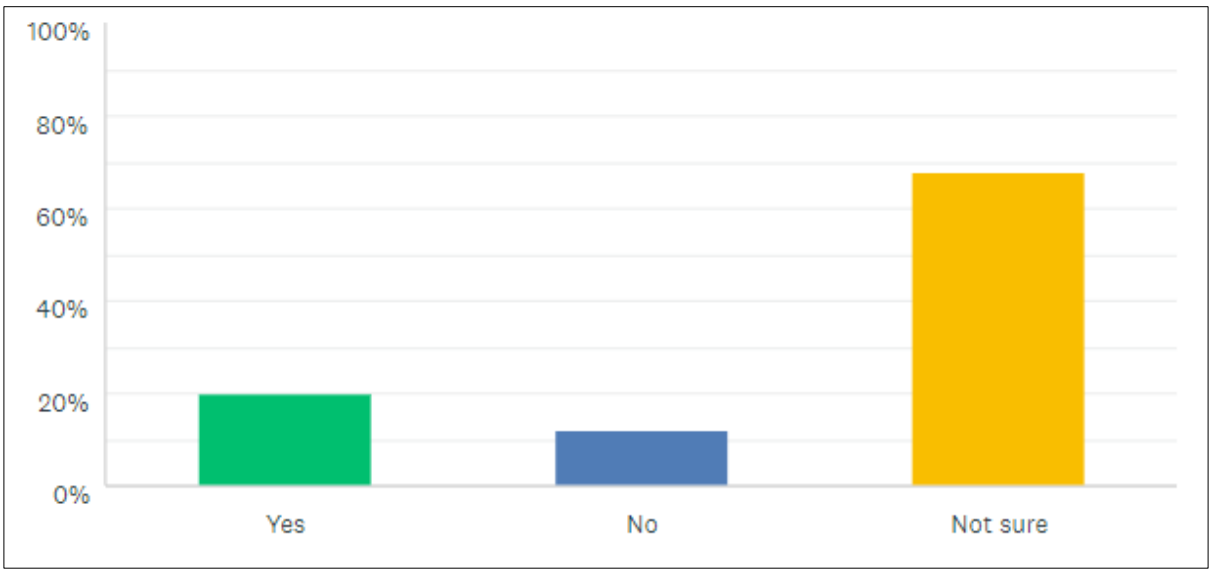

Figure 27: Confirmation of the city's WSUD specifications and guidelines

As reflected in Figure 27, the majority (68%) of the respondents were not sure about the availability of documented WSUD standards, specifications and guidelines in the City of Windhoek. This is despite 52% of the respondents confirming the availability of these management tools in the CoW. It can therefore be inferred that these documents are only fully known to or controlled by a smaller section of the CoW employees and not fully communicated to all stakeholders. The 20% responses that confirmed the availability of these legal instruments also amplified the point of poor WSUD awareness among CoW employees. Only a smaller fraction (12%) of the respondents confirmed the absence of documented WSUD standards, specifications and guidelines in the City. The uncertainty among most of the respondent's point to challenges to WSUD implementation within the City of Windhoek.

4.5.4 Assessment of WSUD as part of CoW Integrated Water Resource Management Plan

This question was included in the research survey to test the respondents' understanding of WSUD options currently included in the CoW IWRM Plan. In addition to testing their WSUD understanding, answers to this question will assist in achieving the research objective of providing a detailed review of the current WSUD options implemented in the CoW. The participants' responses are indicated in Figure 28.

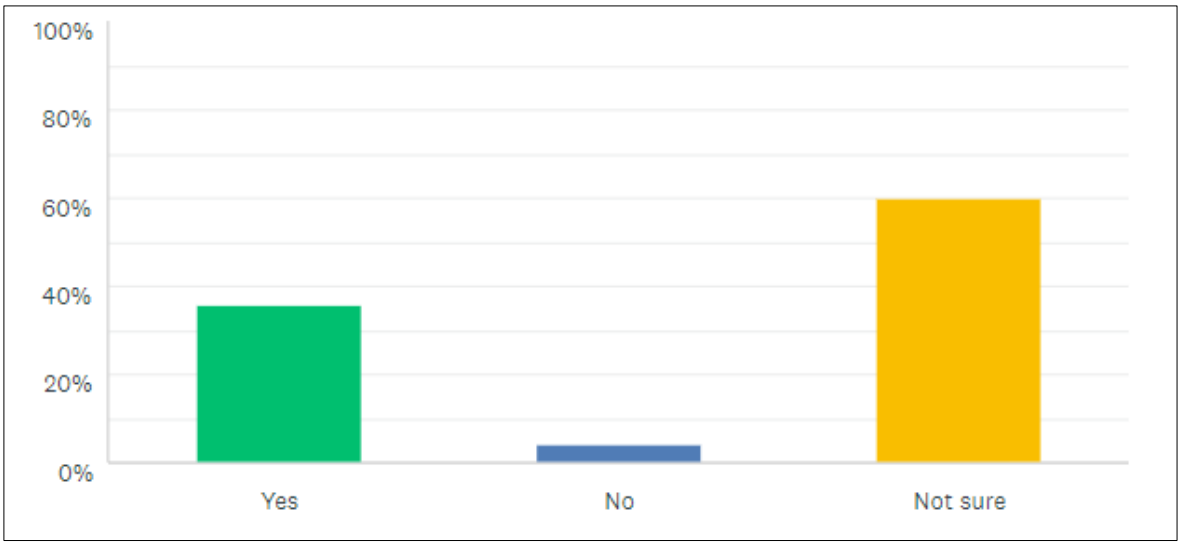

Figure 28: The participants' views on the inclusion of WSUD in the city's IWRM Plan

The majority (60%) of the respondents were unsure whether WSUD is currently part of the city's IWRM Plan while one of the respondents (4%) indicated that WSUD is not part of the IWRM Plan. This feedback is related to the previous question on lack of shared information – with most participants being unsure about the presence of documented standards, specification and guidelines pertaining to WSUD. The respondents might not necessarily have been acquainted with the CoW IWRM Plan at the time of responding to the survey. However, 36% of respondents confirmed the inclusion of WSUD options in the plan, which indicates that there is a significant number of CoW employees who know about this.

4.6 The respondents' views on gap analysis of WSUD within City of Windhoek

4.6.1 Assessment of financial benefits of WSUD to the City of Windhoek

As Gardiner and Hardy (2005) explained, there is a strong perception that WSUD is too expensive and might not necessarily generate financial benefits for the organisation. The respondents of this survey were thus requested to share their views on whether WSUD is beneficial to the City of Windhoek. Figure 29 indicates responses on the financial benefits of WSUD to the City of Windhoek.

As indicated in Figure 29, all the respondents (100%) agreed that the implementation of WSUD within the CoW generated financial benefits. This outcome was expected as most of the respondents shared the same sentiments about the importance of WSUD implementation in the City of Windhoek. All things being equal, there is no doubt that all the relevant parties involved in the planning, design and management of urban infrastructure within the City of Windhoek indicated a willingness to enforce WSUD implementation.

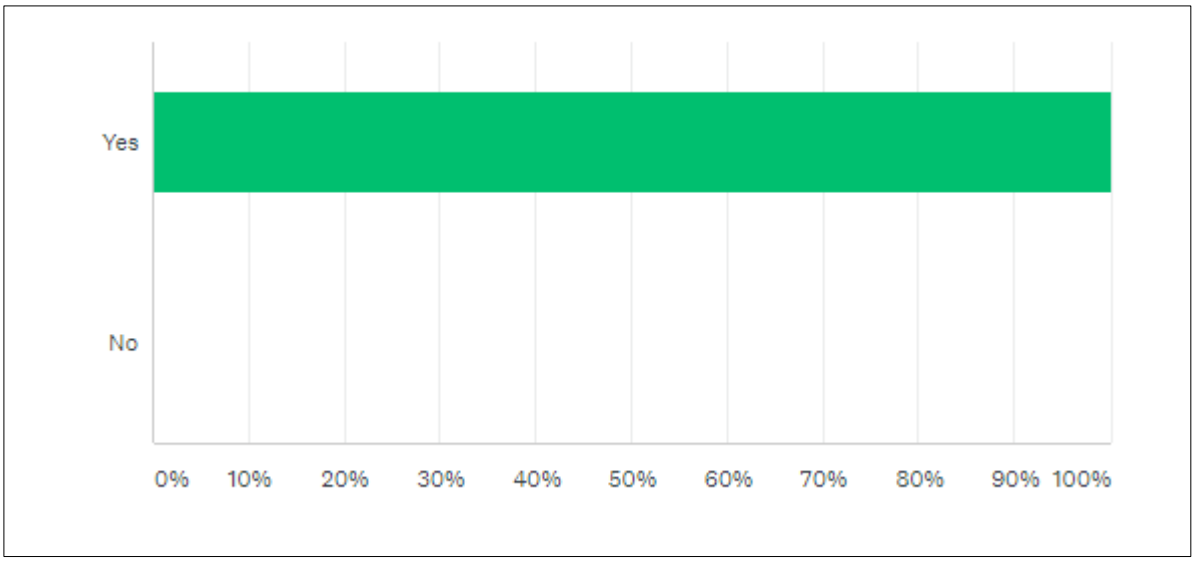

Figure 29: The participants' views on the financial benefit of WSUD to the CoW

4.6.2 Assessment of barriers to WSUD implementation within the CoW

Myers *et al.* (2013) argued that there are several barriers that inhibit WSUD implementation. Similarly, participants of this survey were given the same barriers to indicate which of those impeded the implementation of WSUD within the CoW. The participants' responses regarding existing barriers are indicated in Table 6.

Table 6: The participants' responses to existing WSUD barriers in the CoW

WSUD barriers description	Frequency	Percentage
Lack of capacity, i.e. human or financial	16	64%
Fragmented approach to WSUD implementation, i.e. poor coordination	15	60%
Lack of knowledge and understanding of WSUD	14	56%
No perceived financial benefit of WSUD to the city	12	48%
Lack of management support	11	44%
Absence of legislation and policy to support WSUD	10	40%

As reflected in Table 6, most of the respondents indicated lack of capacity, a fragmented approach and lack of WSUD knowledge as the top three barriers to the implementation of WSUD within the CoW. This suggested that the barriers to WSUD implementation within the CoW were related to lack of capacity, poor coordination and lack of WSUD knowledge within the organisation.

No perceived financial benefit, lack of management support and the absence of legal instruments all scored at least 40%. This score is relatively high and can be correlated to the work of Roy *et al*. (2008) and Myers *et al*. (2013) who identified WSUD legislation and policies as key drivers of WSUD implementation.

4.6.3 Assessment of how to overcome barriers to WSUD implementation within the CoW

In order to validate the answers to the survey questions on barriers pertaining to the implementation of WSUD, the respondents were asked open-ended questions as to how these barriers could be addressed. The answers to this question will assist in making meaningful recommendations pertaining to WSUD implementation. Comments from the 21 respondents are provided in Table 7:

Table 7: The participants' recommendations to address identified WSUD barriers

Respondent	Comments provided as recommendations to address barriers
1	*Need management buy-in and coordinated planning of urban infrastructure. Need documented policies and guidelines to enforce WSUD practices.*
2	*Introduce robust awareness programme. Management should support and expedite the adoption of a broad range of tools aimed at WSUD.*
3	*Review and restructuring of the section or responsible entity within the company responsible for the implementation of the WSUD. The latter should be guided by means of an investigation into how the WSUD ties into the company's' goals and objectives.*
4	*Better management and maybe more priority to the subject matter.*
5	*It is very important to re-emphasise the importance of mainstreaming WSUD in the city's operations as a means to strengthen the city's adaptive capacity to the imminent impacts of climate change, urbanisation and other environmental challenges*
6	*Get management buy-in by demonstrating the benefits of WSUD*
7	*Educate people more on WSUD!*
8	*Provide training/education.*
9	*By availing needed capacity and financial resources due to the high population growth rate that leads to high demand of water supply, taking into account the current drought situation that the country is experiencing or has experienced over the past few years due to climate change*
10	*Vigorous awareness campaigns need to be carried on to bring all on par. Perhaps a workshop for all councillors and officials to educate them and explain their roles and responsibility. In addition, benchmarking with other cities can also assist.*
11	*The departments directly involved with WSUD need to make it a crucial matter by implementing sessions or workshops to educate our staff members on this subject. I can honestly say that as a CoW staff member I have never heard of WSUD in such detail. I also think that a budget must be set aside to address this subject in a serious manner as it can affect us economically.*
12	*Advocacy and raising awareness at all levels (beneficiaries, residents) and regulator (CoW)*
13	*By sourcing money from the central government and open the water supply to other agents not only NamWater*
14	*Implement better internal communication strategy*

15	*Education of key stakeholders and decision makers.*
16	*Coordination from all technical departments to ensure water sensitive urban design is implemented and all activities should consider water conservation*
17	*Integrated planning and coordination*
18	*Develop policy framework and make a specific department responsible*
19	*Find external sponsors and forming PPPs*
20	*Awareness raising on benefits associated with these initiatives*
21	*Should be part of the transformational strategic plan*

Using the Survey Monkey word cloud and content analysis of the participants' comments, their recommendations primarily addressed three barriers:

i) The need to conduct vigorous WSUD awareness campaigns,

ii) Capacity building through training CoW employees and obtaining donor funding to implement WSUD, and

iii) Integrated urban infrastructure planning to better coordinate WSUD initiatives within the City of Windhoek.

4.6.4 Assessment of City of Windhoek as a Water Sensitive City

One of the objectives of this study was to confirm whether the CoW can be considered as 'Water Sensitive City'. As explained by Armitage *et al*. (2014) and Wong (2007), a Water Sensitive City must give due prominence to water as reflected in the design, planning and management of its infrastructure. The participants were requested to give their opinions through a closed question on whether Windhoek had lived up to the aspirations of being a Water Sensitive City. The participants' responses to the question as to whether Windhoek can be considered a Water Sensitive City are indicated in Figure 30.

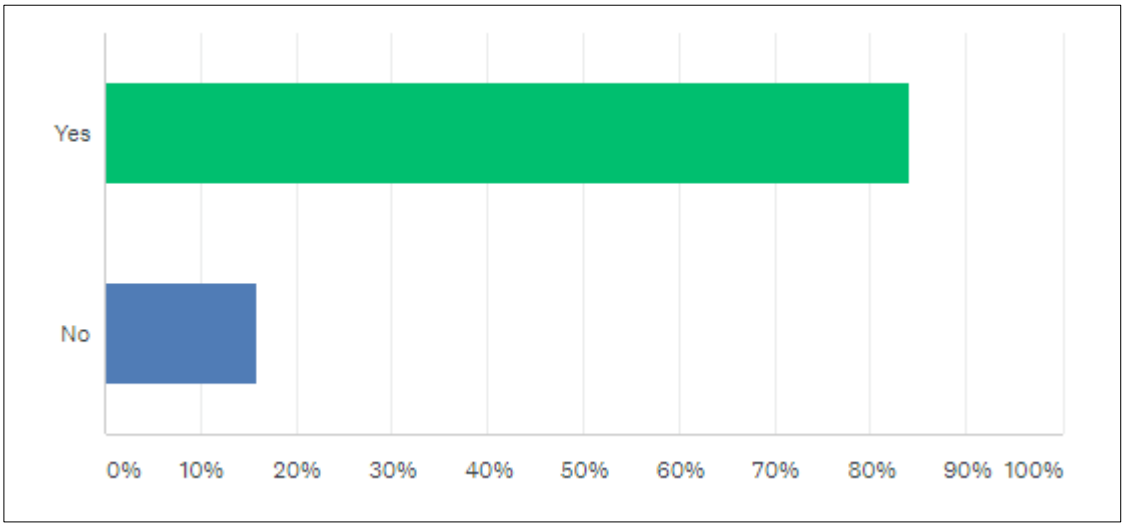

Figure 30: The participants' views on the City of Windhoek as a Water Sensitive City

As indicated in the figure above, the majority of the respondents (84%) thought that Windhoek was a Water sensitive City while only 16% disagreed. To clarify their responses, the participants were further probed via an open-ended question to motivate their choice. Comments from those 19 respondents are provided in Table 8.

Table 8: Motivations why Windhoek is a Water Sensitive City

Respondent	Comments on why the City of Windhoek is a Water Sensitive City
1	*Windhoek is the only town in the world that does wastewater recycling. It means Windhoek is ready to be a role model of WSUD. The only thing lack is a management buy-in into the whole concept so we can enforce the WSUD practices.*
2	*Since Namibia is a dry country, and many people have migrated to the capital city of Namibia (Windhoek), the high population density of the city has increased the likelihood of high water demand. This will have a negative impact on the sensitivity of water in the city.*
3	*Opportunities revolving around WSUD are immense. CoW should demonstrate strong leadership.*
4	*The recent drought and associated water crisis of the past years have driven CoW towards a water sensitive city. Inhabitants have been well informed and educated on the requirements to sustain a safe supply of water and hence drive the water sensitive approach. So Windhoek is a crisis-induced water sensitive city, yes, but needs to improve to achieve the objectives of a fully compliant water sensitive city.*
5	*We have a very well managed water management strategy in place due to the scarcity of water in central Namibia.*
6	*Windhoek has embraced the fact that we are a water stressed city and this will be exacerbated by climate change and as such has adopted various measures to improve water sustainability (such as water reclamation since 1968 and water demand management strategy). But the mainstreaming of WSUD will also contribute significantly to the improvement of water sustainability and put us in a resilient developmental trajectory.*
7	*Windhoek was under extreme pressure during 2016/17 when the dams were empty and currently we are again on the edge of the next severe drought.*
8	*A lot of awareness and education on water sensitive designs and the benefits thereof can still be done.*
9	*Windhoek is running out of water day by day so it is bound to become a water sensitive city.*
10	*Utilise the runoff and make use of reclaimed water*
11	*Council should avail training opportunities to the current work staff and employ more technical staff that will push the WSUD with the city and this could spill over to other towns in the long run.*
12	*The current supply is not adequate to cater for the growing demand and the impacts of climate change will exacerbate the water scarcity.*
13	*We are a water sensitive city because we are affected by very low dam levels in certain parts of the year especially in the past plus minus 5 years. As a result, we have taken measures to curb the unnecessary*

	waste of water by implementing regulations to the users. But we need to do more to solve this problem by implementing and moreover prioritising WSUD at the CoW.
14	*Windhoek does not receive enough water and it does not harvest enough water.*
15	*There are underground water resources that are important to the city and needs to be managed*
16	*No perennial rivers and prolonged draught seasons*
17	*Lack of rainfall / water shortages are a recurring phenomenon, thus continuous monitoring of consumption usage is unavoidable.*
18	*Water is scarce, and we need to preserve it.*
19	*We are already sensitive to water and the scarcity thereof. We should just build on this and make WSUD part of our everyday life.*

It can be seen from the responses that there is a strong correlation between the themes in responses and the literature. For instance, according to Wong (2007), WSUD was first introduced to address water management challenges faced by Australia. The respondents clearly indicated that Windhoek has been dealing with a water scarcity situation for decades as a result of its geographical location, poor rainfall and ever-increasing water demand due to urbanisation. As a result, the CoW has implemented various measures aimed at IUWM within the city. These measures include waste water reclamation; Water Demand Management (WDM) and Managed Aquifer Recharge (MAR). This is an indication that Windhoek has moved a step in the right direction to become a Water Sensitive City. However, the survey and interviews have shown that the WSUD concept has not been fully explored as yet. There is no doubt that a significant amount of work needs to be done to transform Windhoek into a truly Water Sensitive City.

4.6.5 Assessment of factors that will promote WSUD in the City of Windhoek

The last part of the survey was aimed at gauging the participants' responses to what the City of Windhoek can do to promote and enforce WSUD implementation. The intention of this open-ended question was to allow the participants to be innovative and think outside the box by proposing new ideas aimed at accelerating the implementation of WSUD in the city. A total of 19 respondents reacted to the question. Their comments are provided in Table 9.

Table 9: Recommendations to promote WSUD in City of Windhoek

Respondent	Comments provided as recommendations to promote WSUD
1	*Draft policies and regulations regarding WSUD for Windhoek – Development of WSUD guidelines to be used by all developments within the City - Management buy-in from Council and entire administrative management on the concept of WSUD*
2	*Improve coordination on WSUD and provide the necessary training on WSUD*
3	*WSUD should be ingrained indefinitely in CoW's strategic plans*
4	*1. Identifying all requirements and socio-economic benefits of WSUD,*

	2. Assess how it ties into the organisation's corporate scorecard, *3. Align the latter,* *4. Identify areas where CoW lacks in terms of international standards associated with WSUD and then find an economical solution to achieving the identified benefits to the organisation*
5	*Maybe appoint people specifically to deal with WSUD*
6	*This need(s) a dedicated policy framework and the mainstreaming of WSUD in all relevant existing policies*
7	*1. Buy-in from management* *2. Increase knowledge – all stakeholders* *3. Update standards, guidelines and specifications* *4. Implement through legislation and policies.*
8	*Management buy-in and support. Need more capacity to drive campaigns and educate residents.*
9	*Establish regulations and enforcements to implement WSUD and to sensitise people more on WSUD.*
10	*Dedication from Council and Mayor, strict enforcement of regulations once in place.*
11	*Through proper planning and coordination by all the respective departments.*
12	*The implementation starts with buy-in by councillors and support of officials. Once the councillors are inducted properly on the benefits of WSUD, implementation will be smooth and fast. The residents also need to be informed properly so that they support the WSUD.*
13	*Create a department that specialises directly in WSUD. We need specialised experts in this field to educate and implement the necessary tools amongst ourselves.*
14	*Policy directive. (Regulations, standards and clear procedures)*
15	*Education of key stakeholders and decision makers. Commitments from the above development of policies, legislation and implementation plans.*
16	*To fully enforce their policies and regulations in place and consider new innovative and approaches to the matter.*
17	*Make it part of all our regulations and implement and apply it. That is normally where we fail to implement and police it*.
18	*Coordination and awareness raising.*
19	*Allocated more funding to involve expertise and implementation.*

The wide range of opinions pertaining to the existence of WSUD legal instruments within the City of Windhoek highlights that there are no clear legal instruments pertaining to WSUD. However, the majority of the participants share the same sentiments on the need to develop specific policies and regulations pertaining to WSUD to better coordinate WSUD within the CoW. There is also general agreement on the need to develop specific WSUD guidelines that can be easily enforced. The issue of existing WSUD legal instruments in the City of Windhoek was clarified through personal interviews with selected stakeholders in the city (discussed in the next section). There is a need for the CoW to re-look its current organisational structure and to clearly define roles and responsibilities as far as WSUD is concerned.

4.7 Summary of personal interviews, data and analysis

Two respondents were interviewed after all the participants had completed the survey questionnaire. The selection criteria were purely based on selecting participants who could address the shortcoming identified in the survey response. The selected employees were highly experienced professionals. One had a Bachelor's degree and one a master's degree. The interviews were recorded to make transcription easier and to keep the interviews short by not wasting time writing while asking questions. The responses of the two people who were interviewed are summarised below.

Interviewee 1 – Chief Engineer: Bulk Water and Waste Water

The interviewee indicated that he had knowledge and understanding of the WSUD concept from his academic background. According to the interviewee, the concept is not well known within the organisation as even he, who was the divisional manager responsible for all operations and infrastructure management pertaining to water, was only familiar with certain operational measures aimed at water conservation within the City. He further expressed concern that there is a silo mentality in the organisation pertaining to urban infrastructure management and design at large, inherently due to the Council's organisational structure. This is evident from the fact that the water and waste infrastructure was being run by one department, while stormwater was overseen by the Roads Department. He thus agreed that there was no proper coordination of WSUD activities due to these historically inherent structural setups. He strongly argued that there is a significant interdependence between water, wastewater and stormwater. Hence, there is a need for an integrated approach towards the design and management of this infrastructure.

Asked about what management instrument currently exists within the City of Windhoek pertaining to WSUD, he clearly indicated that there was no specific policy, regulations and guidelines on WSUD; there was only the City of Windhoek's Water Supply Regulations and Integrated Water Management Plan that supported some of the WSUD activities. For instance, Water Demand Management is clearly included in the regulations and forms the legal basis on which City of Windhoek enforce water restrictions through public notices and block water tariffs to discourage the over-usage of water.

Asked about specific WSUD activities currently practised in Windhoek, he indicated the following WSUD activities as derived from the current policy instrument mentioned earlier:

1) Water Demand Management via Demand Reduction and Rising Block Water Tariffs from Water Supply Regulations
2) Water recycling from the city's IWRM Plan
3) Green roofs are currently installed voluntarily by property developers to achieve green certification of their buildings.

A selected number of residents are voluntarily using rainwater harvesting tanks at their premises for gardening and swimming pools during Council water restrictions.

Due to the absence of legal instruments and specifications pertaining to WSUD, he strongly believed management was not fully committed to implementing WSUD. However, he acknowledged that this shortcoming was attributed to lack of knowledge and awareness

towards WSUD and believed there was a need for them as middle management to sell the idea to Council and draft relevant policy, regulations and even specific guidelines for their approval that can be shared with all external stakeholders such as consulting engineers, developers and architects. He believed that Council would support all WSUD if properly motivated, having already approved the expansion of waste water recycling and Managed Aquifer Recharge (MAR) to ensure the sustainability of water supply to the city.

Interviewee 2 – Engineer: Urban Planning and Design

The interviewee indicated that he had knowledge and understanding of the WSUD concept from his academic background. According to the interviewee, the concept was not well known within the organisation as evidenced by that fact that he, who was responsible for the planning and design of roads and stormwater, was mainly guided by the City of Windhoek's Supply Regulations, which makes specific reference to South African Bureau of Standards (SABS) specifications. He further expressed that in addition to those specific regulations, the Department of Urban Planning was also guided by the City of Windhoek's Integrated Water Management Master Plan in terms of the planning and design of its urban infrastructure. He confirmed that the CoW does not have specific policy, regulation and guidelines on WSUD, and that all WSUD activities currently conducted in the city were either inherently part of the SABS specifications on urban infrastructure planning and designs, or as supported by the CoW Supply Regulations.

Asked about existing WSUD options in Windhoek, he indicated the following WSUD options:

1) The interviewee indicated having knowledge of permeable pavements. However, the city does not specifically advocate its implementation.
2) The interviewee indicated having knowledge of wetlands.
3) The interviewee indicated having knowledge of litter traps within stormwater infrastructure. However, this was not common within the city.
4) The planting of vegetation along road strips
5) Water Demand Management via Demand Reduction and Rising Block Water Tariffs from Water Supply Regulations
6) Wastewater reclamation through the Goreangab Water Reclamation Plant (GWRP)
7) Green roofs are currently implemented voluntarily by property developers in order to achieve green certification of their buildings.
8) A few residents are voluntarily practicing rainwater harvesting via tanks at their premises for use in the irrigation of gardens and for swimming pools, especially during Council water restrictions.

Asked about how often planning engineers liaise with other counterparts within the CoW in designing water infrastructure, he confessed that at the moment it was not necessary as each department was responsible for its own infrastructure planning and design. When pressed whether the current practice promoted WSUD implementation, he acknowledged that the current organisational structure did not promote WSUD and that there was a need for coordination and structural reform to fully implement WSUD in the City of Windhoek.

The interviewee further stated that the absence of legal instruments and specifications pertaining to WSUD was certainly responsible for the uncoordinated and slow implementation of WSUD in the city. He believed that as a technocrat he can only suggest that management look into formalising WSUD through policies and procedure. Asked about why WSUD policies were not yet developed, he said that he '*does not believe that Councilors are knowledgeable to request such policies, hence it must be a bottom-up approach where technocrats that are well vested with the benefits of WSUD must recommend to Councilors to have such legal instruments in place'.*

4.8 Concluding remarks

This chapter presented the data and discussions of the research findings of the study. The study has provided a review of all the WSUD options that currently exist within the City of Windhoek, and identified gaps and barriers that impede implementation. The study also identified critical barriers to WSUD implementation, with the absence of CoW policies, regulations and guidelines on WSUD being a source of major concern. Although the survey findings were generally consistent with the literature reviewed, the study noted some inconsistencies which were addressed by conducting interviews with selected participants to clarify the contradictions. The final chapter of the study will provide conclusions and recommendations based on the outcomes of this study.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of the work presented in this mini-dissertation. Key findings are used to answer the research questions and to show how the objectives of the study were achieved. Finally, drawing from the findings, the chapter makes recommendations to the City of Windhoek's management on how to better implement Water Sensitive Urban Design (WSUD) practices to the benefit of Windhoek and its inhabitants.

5.2 Existing level and knowledge of WSUD within the City of Windhoek

The study established that there is a clear understanding and knowledge of WSUD concepts among the CoW technocrats, which include engineers, managers, urban planners and environmental managers, mostly due to their academic knowledge and some WSUD practices within the city to which they have been exposed. The existing WSUD options are derived from the CoW Water Demand Management policies and Water Supply Regulations which are all aligned with the national Integrated Water Resource Management Plan (2010), as well as the voluntary green initiative by the city developers to achieve green building status. It clearly emerged that WSUD is not a familiar concept in the CoW. Hence, it can be concluded that the concept of WSUD has not been fully explored within the CoW and that a significant amount of work still needs to be done for Windhoek to be transformed into a Water Sensitive City.

5.3 Existing WSUD within City of Windhoek

Out of the main categories of WSUD identified in the literature review chapter, the study revealed that the WSUD practices implemented within the CoW are mainly those related to Water Demand Management and water re-use. It was found that green roofs and rainwater harvesting were installed on a voluntary basis. The study revealed that the main WSUD practices (Water Demand Management, water re-use) in Windhoek have come about from inclusion in the WDM policies, Water Supply Regulations and the Integrated Water Resources Management (IWRM) Plan. The existing WSUD options are as listed below:

i) Water Demand Management via water restrictions

ii) Water Demand Management via rising block water tariffs

iii) Water recycling / recycled water reuse

iv) Voluntary green roofs by developers

v) Voluntary rainwater harvesting tanks.

From these findings it is evident that stormwater management, in particular Sustainable Drainage Systems (SuDS), has not been fully explored as the practices that exist were implemented on a voluntary basis. This can be attributed to the lack of existing legislation to support and enforce the implementation of SuDS.

5.4 Existing barriers to WSUD implementation within the City of Windhoek

The literature has revealed that WSUD is not generally implemented without impediments. According to Lottering (2011), impediments pertaining to WSUD implementation fall into four categories which are identified as regulatory frameworks, knowledge on the design of WSUD tools, the cost of implementation and, lastly, marketing and community acceptance of the WSUD activities. There is a close correlation between literature and the findings of this study which established the following as barriers to WSUD implementation within the CoW:

i) Lack of capacity

ii) Fragmented approach to WSUD implementation

iii) Lack of knowledge and understanding of WSUD

iv) No perceived financial benefit of WSUD to the city

v) Lack of management support

vi) Absence of legislation and policy to support WSUD.

Although the survey initially indicated the presence of legislation that supports WSUD, it became evident through further analysis and interviews that the biggest barrier was a lack of specific policies, regulations and guidelines on WSUD implementation within the CoW. It has emerged that the existing policies and legislation supported Water Demand Management (WDM) and water reclamation, which are aligned with the national Integrated Water Resource Management Plan, and that the WSUD concepts are only partly included in existing policies, legislation and the Integrated Water Resource Management Plan. There is thus a need for a governance environment that fully supports the implementation of the WSUD concepts. Policies, regulations, guidelines and standards that solely promote the implementation of WSUD are lacking within the CoW. This needs to be addressed if Windhoek is to be recognised as a Water Sensitive City.

Lack of WSUD knowledge can be attributed to a lack of management support since it emerged that there was no appreciation of the benefits of WSUD implementation among the City of Windhoek and its residents.

The study has revealed that there is a fragmented approach towards the management of water, wastewater and stormwater within the CoW. This is of great concern as an integrated approach is required for the successful implementation of WSUD within any urban setting. Literature has revealed that water cycles, drainage solutions and behavioural aspects combine to create a ‘wicked problem’ (Malulu, 2016). According to Malulu (2016), a ‘wicked problem’ is a special kind of problem that cannot be solved by linear type of thinking, but requires systems thinking or an understanding of complexity theory. Malulu (2016) further explained that no level of linear thinking can present a workable solution to problems that are characterised as ‘wicked’. The implementation of WSUD can also be characterised as a ‘wicked problem’. As such, it can be concluded that WSUD within the City of Windhoek cannot be effectively implemented with the fragmented management approach that currently exists within its regulatory environment. Successful implementation will therefore require an integrated and interdisciplinary approach toward WSUD at the city.

5.5 Recommendations to address WSUD gaps and accelerate WSUD implementation by the city

Based on the objectives of the study, findings and conclusions, the following recommendations can be made (in no specific order):

1) Develop WSUD policies, regulations, specifications, standards and guidelines for the City of Windhoek, taking into consideration existing practices.
2) Create WSUD awareness campaigns for the entire organisation including Councillors.
3) Review the organisational structure and clearly outline the roles and responsibilities of the relevant stakeholders to better coordinate WSUD activities within the CoW.
4) Invest in capacity building to ensure that all stakeholders receive necessary training on the WSUD concept.
5) Develop a communication strategy for WSUD, internally and externally.
6) Appoint WSUD champions to act as pioneers and advocates of WSUD implementation within the city by availing the necessary incentives.
7) Request government funding to enable WSUD implementation at large scale.
8) Advocate for carbon credits on all green buildings.
9) Strictly enforce WSUD policies, regulations and guidelines once approved by Council.

5.6 Conclusions and recommendations for further research

The study achieved the research objectives of identifying WSUD practices currently practised within the City of Windhoek. It was evident that all existing WSUD practices were derived from the city's Water Demand Management policies and regulations and the Integrated Water Resource Management Plan. Although the study revealed various barriers to WSUD implementation within the City of Windhoek, the absence of legal instruments such as specific policies and regulation was identified as the main contributing factor to the slow uptake of WSUD in Windhoek.

Based on the research findings, the following recommendations can be made in terms of future research:

- **Better integration of the water management approach**: A fragmented and silo approach towards water management among the CoW stakeholders was identified as one of the main barriers to WSUD implementation. Future research on this topic can help to shed light on better WSUD implementation.

- **Better collaboration between stakeholders**: The research did not assess the collaboration between the national water provider (NamWater), the City of Windhoek and the national government on how to best coordinate and share resources to fully realise and achieve integrated WSUD implementation at a national level. As such, this is also an area of future research.

- **Putting policies and regulations in place**: Since the development of specific WSUD policies and regulation is inevitable, as highlighted in this study, future research could investigate how best the CoW can ensure that these legal instruments are put in place.

- **Improving basic services in informal settlements**: The researcher has noted that the lack of basic services in informal settlements can hamper the implementation of WSUD and the establishment of Windhoek as a Water Sensitive City. As such, there is a need for the integration of the informal settlements into the rest of the city, if Windhoek is to be transformed into a Water Sensitive City. Future research can look at ways to address the basic services challenge in informal settlements and to implement Sustainable Urban Drainage Systems (SuDS) in these settlements.

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APPENDIX A: SURVEY QUESTIONAIRE

INTRODUCTION

Water Sensitive Urban Design (WSUD) within City of Windhoek

Review and Gap Analysis of Water Sensitive Urban Design (WSUD) within City of Windhoek

My name is Linekela Nambinga, a Master of Philosophy (MPhil) in Urban Infrastructure Design & Management student at the University of Cape Town and currently employed as a Civil Engineer at Consulting Services Africa (CSA). I am conducting research for my thesis pertaining to Review and Gap Analysis of Water Sensitive Urban Design (WSUD) at Windhoek municipality. The letter of permission to conduct the research within the City of Windhoek is herewith attached. The outcome of this research will be beneficial to the City of Windhoek and thus aims to deliver the following outcomes;

1) Confirms if the concept of WSUD is advocated for by the City of Windhoek.

2) Validate whether the City of Windhoek implemented WSUD within the City.

3) Provide the detailed review of the current WSUD implemented within the City of Windhoek.

4) Identify existing gaps pertaining to WSUD within the City of Windhoek if any and make recommendation on how they can be addressed.

To achieve the above objectives, I am kindly requesting you to spare a few minutes of your valuable time to complete this questionnaire. Please note that your participation in this survey is completely voluntary and your response will be anonymous. Survey results will strictly be used for the purpose of this research. Should you be interested in the outcome of the study, copy of the final research will be made available to all participants.

Thank you so much for sharing your experience and knowledge on the subject matter.

PART 1: DEMOGRAPHIC INFORMATION

* 1. What is your age?

- ◯ 17 or younger
- ◯ 18-20
- ◯ 21-29
- ◯ 30-39
- ◯ 40-49
- ◯ 50-59
- ◯ 60 or older

* 2. What's is your Job title?

- ◯ Chief Engineer or Architecture/Divisional Manager
- ◯ Engineer/Technician
- ◯ Environmentalist/Environmental Officer
- ◯ Section Engineer/Section Head
- ◯ Town/Urban Planner

* 3. In what department of the City are you currently employed?

- ◯ Economic Development
- ◯ Infrastructure, Water and Technical Services
- ◯ Urban Planning

* 4. How long have you been working for the City of Windhoek?

- ◯ Above 3 to 5 years
- ◯ Between 2 to 3 years
- ◯ Less 1 year
- ◯ More than 5 years

* 5. What's your highest qualification?

- ◯ Bachelor of Science
- ◯ Bachelor of Technology
- ◯ Certificate
- ◯ Diploma
- ◯ Doctorate
- ◯ Master Degree

PART 2: REVIEW AND KNOWLEDGE OF WSUD CONCEPT

* 6. Do you have knowledge and understanding of the WSUD concept?

- ◯ No
- ◯ Not sure
- ◯ Yes

* 7. Is there coordination as far as WSUD is concerned amongst all stakeholders involved in City Urban Planning i.e Engineers, Urban Planners, and Architects etc.?

- ◯ No
- ◯ Not sure
- ◯ Yes

* 8. I believe WSUD is critical to the City?

- ◯ Agree
- ◯ Cannot say
- ◯ Disagree

* 9. Select all WSUD currently practiced within the City of Windhoek at Building and Household level?

- ◯ Grey/Black water re-use
- ◯ Rain Gardens
- ◯ Roof Garden/Green Roof
- ◯ Stormwater harvesting e.g Rain Water Tanks
- ◯ Water Demand Management

* 10. Select all WSUD tools/options currently practiced within City of Windhoek at street and neighborhood level?

- ◯ Bioretention systems for streetscapes
- ◯ Gross pollutant traps
- ◯ Permeable pavements
- ◯ Swales and buffer strips i.e Vegetation strips at drainage points

* 11. Select all WSUD tools/options currently practiced within City of Windhoek at precinct/large scale level?

- ◯ Constructed Wetlands i.e Rain Garden at large scale
- ◯ Retention Ponds
- ◯ Wastewater management

* 12. Which City of Windhoek department is responsible for WSUD?

- ◯ Both.
- ◯ Don't Know
- ◯ Economic Development
- ◯ Infrastructure, Water and Technical Services
- ◯ Urban Planning

PART 3: CITY OF WINDHOEK MANAGEMENT COMMITMENTS TO WSUD VIA POLICIES AND REGULATIONS

* 13. Is management fully committed to WSUD?

- ◯ No
- ◯ No sure
- ◯ Yes

* 14. What management instruments currently exist to enforce WSUD within the City of Windhoek? Select all that is applicable.

- ◯ None
- ◯ Policies
- ◯ Regulations
- ◯ Standards, Guidelines and Specifications

* 15. Does the City have documented standard designs and specifications on WSUD?

- ◯ No
- ◯ Not sure
- ◯ Yes

* 16. Is WSUD part of the City of Windhoek Integrated Water Resource Management Plan?

- ◯ No
- ◯ Not sure
- ◯ Yes

PART 4: GAP ANALYSIS OF WSUD

* 17. Do you think there are any financial benefits to the City in implementing WSUD?

- ◯ No
- ◯ Yes

* 18. What are the shortcomings or barriers to WSUD implementation within the City of Windhoek? Select all that is applicable.

- ◯ Absence of legislation and policy to support WSUD
- ◯ Fragmented approach to WSUD implementation i.e poor coordination
- ◯ Lack of Capacity i.e Human or Financial
- ◯ Lack of Knowledge and Understanding of WSUD
- ◯ Lack of Management Support
- ◯ No perceived financial benefit of WSUD to the City

* 19. In your opinion how will the shortcomings/ barriers selected from question 18 above can be addressed by City of Windhoek?

* 20. Would you say Windhoek is a water sensitive city or can be a water sensitive City in future?

- ◯ No
- ◯ Yes

* 21. If your answer is yes to question 18 above, please elaborate?

* 22. In your opinion, how can the City of Windhoek fully implement WSUD?

APPENDIX B: CITY OF WINDHOEK PERMISION LETTER

Department of Human Capital
& Corporate Services
59
Corner of 5378 Independence Avenue and Garten Street
WINDHOEK, NAMIBIA
Tel: (+264) 61 290 2911 • Fax: (+264) 61 290 3212 • www.cityofwindhoek.org.na

ENQ: Mr. MA Nikanor
DATE: 07 September 2018

PHONE: 09 264 61 290 2630
FAX: 09 264 61 290 3212
EMAIL: ark@windhoekcc.org.na

RE: REVIEW AND GAP ANALYSIS OF WATER SENSITIVE URBAN DESIGN (WSUD) IN WINDHOEK, NAMIBIA – MRS. LINEKELA NAMBINGA (STUDENT NO: NMBLIN001)

This letter serves as confirmation that Mrs. Linekela Nambinga **(STUDENT NO: NMBLI001)**, a student pursuing a Master of Philosophy in Urban Infrastructure Management & Design at the University of Cape Town, has been granted permission to conduct her research on the above subject within the City of Windhoek.

The research, which is in partial fulfilment of the studies, aims to review and conduct a gap analysis of Water Sensitive Urban Design (WSUD) within the municipality of Windhoek. Ultimately the student aims hopes to validate if the concept of WSUD is applied by the City of Windhoek and make recommendation on how it can be enhanced through identification of existing gaps to the benefit of the City and its residence.

Respondents to the study are therefore requested to render Mrs. Linekela their cooperation and assistance. Should there be any queries, please feel free to contact the Human Resources Development Division on the above contact details

Yours Sincerely

MA Nikanor
Manager: Human Resources & Organisational Development

APPENDIX C: CITY OF WINDHOEK WATER SUPPLY REGULATIONS

Source: CoW Water Demand Management Plan, 2018.

APPENDIX D: CITY OF WINDHOEK WATER EFFICIENT GUIDELINES

Source: CoW Water Demand Management Programme, 2018.

WATER EFFICIENT GUIDELINES

THE OPPORTUNITY TO SAVE COST WITH IMPROVED LIVING STANDARDS

1. Consider to replace sanitary equipment with modern **water efficient equipment.**
2. Place a water filled **bottle in the toilet cistern** for better efficiency. (less water flushed)
3. **Water efficient shower heads and taps** can save up to 60% water.
4. **Avoid water coolers** as they consume large quantities of water.
5. **Shade the bedding** of trees, shrubs and flowers with mulch, gravel / stone or net.
6. Consider **indigenous and dry gardens** to minimise irrigation water up to 80%.

7. Lawns are not supported by the COW. Restrict lawns to 20m² per residential unit.
8. Reduce irrigation time of **irrigation systems**. Soil humidity meter should be installed. Serviced valves minimum every 3 years to avoid water losses/ malfunction.
9. Pools shall be covered if not in use. Backwash water to drain into the sewer.
10. Water features are not allowed by the COW because of their high water consumption.
11. **Rainwater harvesting** for pool recharge is recommended (min. 0.2 m³/ m² of pool)
12. Rainwater harvesting for fish pond recharge is also recommended (min. 0.5 m³/ m²) Fish pond shall be covered with shade nets to reduce evaporation. No fountains or water falls are allowed to be operated. (except for in-house ponds)

13. Rainwater harvesting is recommended as long as relevant health regulations are adhered to. Prevent mosquito larva from breeding and close tank openings with mosquito gauze.
14. Define your **water quota** and avoid overconsumption. (recommend daily residential water consumption: 90 l/person /day; commercial: 20 l/person /day)
15. **Car wash quota is 30 l/car.** (Water efficient methods are recommended)
16. **Read your water meter** daily or weekly to measure your water consumption. One day's water leak may consumes more water than one month's water savings
17. **Semi-purified** water is a sewer by- product and contains harmful microorganisms. It is suitable for irrigation of landscapes, however not for pools.

18. Semi-purified water requires specific safety procedures. (WSR)
19. **Building plans require** that the main distribution pipes are indicated on plan.
20. Maintenance friendly design for water reticulation systems on building plans, offtake isolation valves and water meters for separate buildings/floors. (WSR)
21. Each flat, building or house shall have a dedicated water meter.
22. Water efficient equipment to be specified on building plans. (WSR)
23. Overflow for geyser and tanks shall be readily visibly (not directly into sewer).
24. Water meter batteries (complex) shall be horizontal wall mounted & protected.
25. Midblock house water supply pipes require straight 110mm sleeve pipe if covered by any structure. Ends accessible for opening and easy inspection.

APPENDIX E: AN EXAMPLE OF CITY OF WINDHOEK PUBLIC INFORMATION

Source: CoW Water Demand Management Programme, 2018.