URBAN HOUSEHOLD UPTAKE OF WATER SENSITIVE URBAN DESIGN MEASURES: A COMPARATIVE EXPLORATORY SURVEY ACROSS THE CITIES OF CAPE TOWN AND TSHWANE

by

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DECLARATION OF ORIGINALITY

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Declaration

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SUMMARY

Population growth, climate change and increasing water consumption threaten the availability and quality of municipal water. In South Africa, climate change accelerates drought conditions leading to severe water shortages in areas such as the Western Cape. Cape Town came close to a day-zero due to drought conditions and excessive municipal water use, with households constituting the largest proportion of municipal water consumers. Water Sensitive Urban Design measures, such as rainwater harvesting, greywater recycling and permeable paving, may be used to help manage and curb municipal water use. This study aims to explore, describe and compare urban household uptake of these measures across the Cities of Cape Town and Tshwane to determine (1) past, present and future uptake, (2) factors influencing uptake, and (3) preference for municipal assistance to implement Water Sensitive Urban Design relative to other demand-side management instruments. A survey was conducted amongst households in standalone houses across suburbs and townships using a standardised questionnaire (N = 250). Significantly larger proportions of households in Cape Town compared to Tshwane took up measures, highlighting day-zero's possible effect. Significant factors were limited to existing water-saving behaviour, income, and home-ownership, while log-linear analyses suggest little difference in the influence of factors between Cape Town and Tshwane. Day-zero is therefore unlikely to cause a more permanent behavioural change in Cape Town. Municipal assistance to implement Water Sensitive Urban Design measures was the second most preferred demand-side management instrument, suggesting a preference for constructive rather than punitive instruments. There appears to be potential for the large scale household uptake of WSUD in South Africa. Therefore, indicating that it may be worthwhile for municipalities, as well as various other water authorities and service providers, to invest in WSUD. Recommendations are made for greater water sensitive urban planning in a South African context

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LIST OF ABBREVIATIONS

BMP	Best Management Practice
BPP	Best Planning Practice
BWD	Basic Water Distribution
CSIR	Council for Scientific and Industrial Research
DSM	Demand-side Management
EBIT	Faculty of Engineering, Built Environment and Information Technology
ESD	Ecological Sustainable Development
FGD	Focus Group Discussion
GAP	Groundwater Abstraction Point
GI	Green Infrastructure
GWR	Greywater Reuse
LID	Low Impact Development
LSC	Little Stringybark Creek
NWA	National Water Act
NWRM	Natural Water Retention Measures
NWRS-2	The second National Water Resource Strategy
PP	Permeable Paving
RSA	Republic of South Africa, or South Africa
RWH	Rainwater Harvesting
RWHT	Rainwater Harvesting Technology
SDGs	Sustainable Development Goals
SEM	Structural Equity Modelling
SPSS	Statistical Package for Social Sciences
SuDS	Sustainable Drainage Systems
SUDS	Sustainable Urban Drainage Systems
SWM	Stormwater Management
TPB	Theory of Planned Behaviour
UK	United Kingdom
UN	United Nations
UP	University of Pretoria
USA	United States of America
VAIL	Value and norms, Awareness, Identity and Lifestyle and life stage (framework)
WC	Water Closet (flushing)

WC	Water Conservation
WDM	Water Demand Management
WSC	Water Sensitive City
WSD	Water Sensitive Design
WSP	Water Sensitive Planning
WSS	Water Sensitive Settlement
WSUD	Water Sensitive Urban Design
WWF	World Wide Fund for Nature

CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 The Significance of Water for Human Life

Water is a precious natural resource. It is critical for supporting various forms of life on earth. For human beings, fresh water is essential for various uses such as cooking, drinking, growing food, and various hygiene practices such as cleaning and washing. About 70% of the earth's surface is covered with water. However, of this 70%, only 1% is considered freshwater. Although an additional 2% of water is also considered freshwater, it is, however, stored in icecaps and, as a result, not accessible for human consumption. Therefore only 1% of the water on earth is available to humans. In addition to sustaining human life, it is crucial for supporting other plant and animal species, i.e. vegetation, birds, reptiles, mammals, and freshwater fish, amongst others. The remaining 97% of the earth's water is salt water, which is not suitable for human consumption (Schneider et al., 1973; Water Wise: Rand Water, 2020).

As highlighted above, the quantity of freshwater is limited. It is therefore important for humans to conserve the water that is available to them. However, in addition to its finite quantity, numerous other factors pose a threat to water availability. These are discussed in detail below.

1.1.2 Status of Water: Globally

As noted earlier, the earth's surface water resources are limited, with humans competing to access these resources with various other users. Moreover, in addition to humans having to share the available freshwater resources with various other forms of life, other factors such as population growth, urbanisation, pollution, climate change, as well as increasing water consumption per capita also impose further constraints on available water resources (Donofrio et al., 2009; Gilbertson et al., 2011).

For instance, increasing population levels can place pressure on available water resources; this pressure is often driven by increases in the demand for water, which leads to water shortages. There are currently just over 7.7 billion people on earth, of which 2 billion are residing in countries that are experiencing high water constraints. Furthermore, the global population is expected to increase to 9.7 billion people in 2050; this, therefore, indicates a growing and imminent threat to global water security (Donofrio et al., 2009; Mnisi, 2020; United Nations, 2020; United Nations, 2020; Worldmeter, 2020).

Another factor influencing global water security is urbanisation. Defined as "the concentration of people in urban areas, and the consequent expansion of those areas" (Schneider, et al., 1973, p. foreword), urbanisation often expresses an increased demand for water. This is because urban areas account for large and growing quantities of water demand and consumption patterns as a result of high population densities that often converge with freshwater resources that are often either limited or, as in some cases, have reached maximum capacity; as well as a result of higher levels of services and access to services found in urban areas (Fisher-Jeffes et al., 2011; Rohr et al., 2017; Mnisi, 2020). The global urban population, which currently stands at 3.9 billion people, is expected to increase to 6.3 billion in 2050, thus placing further strains on existing freshwater resources and urban areas alike (United Nations, 2020).

Pollution constitutes another factor threatening global water security. Population growth along with technological innovations and advances relatively generate and accelerate the pollution of water bodies. Humans produce various kinds of waste; amongst these are solid waste and human waste. Solid waste, which is waste in the form of solid material like glass, paper, and plastic, usually makes its way to water bodies when not disposed of through assigned channels such as recycling and waste bins. On the other hand, human waste is frequently partially treated and conveyed to water bodies which naturally decontaminate the sewage. Therefore, population increases would result in the increased production of waste.

Moreover, some factory plants that manufacture various (and often advanced) products, such as select textiles (i.e. leather) and chemical and electronic products, produce toxic waste, which is also conveyed to receiving water bodies. Such activities, therefore, produce more waste than natural water bodies can assimilate, thus resulting in water pollution. Pollution threatens water quality as polluted water is often considered harmful for consumption, which is not limited to human consumption, thus making pollution a significant threat to water security (Schneider et al., 1973; Water Wise: Rand Water, 2020).

Climate change represents another factor influencing water security. Surface water resources are sustained by precipitation and, as a result, often find themselves vulnerable to water shortages as a result of varying rainfall patterns and drought. Furthermore, additional freshwater sources are found underneath the earth's surface in the form of groundwater. Groundwater is often extracted and used to supplement surface water resources in an effort to reduce the pressure imposed on the surface water source. However, about 33% of the world's major groundwater systems are already distressed.

The various factors posing a threat to South Africa's surface water resources are discussed in the subsequent section.

1.1.3 Status of Water in South Africa

South Africa is a water-scarce country, and many of its citizens are beginning to experience what it means to have less water. The limited availability of freshwater resources, local climatic conditions, climate change, pollution, urbanisation and increasing water consumption per capita are amongst the leading factors posing a threat to the country's water security (Institute for Security Studies, 2018; City of Tshwane Metropolitan Municipality, 2020; Statistics South Africa, 2020; Department of Water Affairs: RSA, 2020).

For instance, South Africa's fresh surface water resources have reached a capacity level of 98%. Although the country already imports a significant portion of its potable water from neighbouring Lesotho, it is estimated that demand will outstrip supply by 2025. Furthermore, South Africa's average annual rainfall is 492mm; this is slightly less than half of the global average annual rainfall, which stands at 985mm (Fisher-Jeffes et al., 2011; Statistics South Africa, 2020; Water Wise: Rand Water, 2020).

Moreover, as much as South Africa's local climatic condition is partly to blame for current pressures placed on water resources, climate change has accelerated shortages as experienced through recent droughts. To date, many parts of the country remain drought disaster zones. South Africa's western coast and the Karoo are some of the most-hit areas due to droughts. For instance, the City of Cape Town – a major metropolitan area along South Africa's southwest coast – was recently hit by severe water shortages resulting from drought and excessive municipal water consumption practices. Between February and September 2018, the potable water supply for the City of Cape Town's residents was reduced to 50 litres per person per day (i.e. 50ℓ / p / day). In addition to these restrictions, the City counted down the days to a then inevitable "day-zero". Day-zero represents the day in which 75% of the City of Cape Town's reticulation system was supposed to be turned off. The City had planned to have residents collect water supplies from collection points, i.e. from day-zero and indefinitely after that. The City of Cape Town was, however, able to avoid a day-zero as a result of early winter rains, as well as a mutual decision by Western Cape farmers to share some of their allocated water with the City's residents (Institute for Security

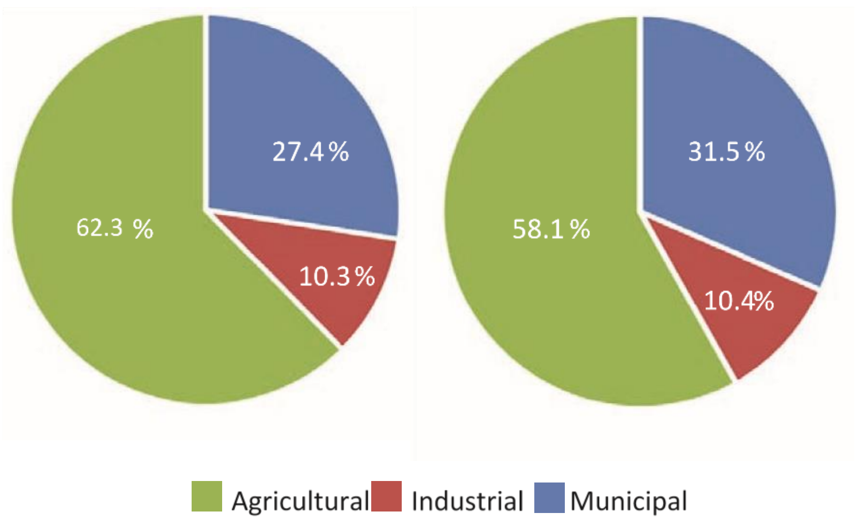
Studies, 2018; Jacobs-Mata et al., 2018; Sinclair-Smith & Winter, 2018; Gosling, 2019; Palafox Jr, 2019).

Pollution, as a result of the actions of human inhabitants and poor resource management, is another major factor influencing water security in South Africa. For example, the recent deterioration of the quality of water in the Vaal Dam results from causal human actions and poor resource and infrastructure management. For instance, the malfunctioning sewage pumps resulted in effluent conveyance into the dam, consequently polluting its water. However, maladministration and the mismanagement of funds resulted in a lack of maintenance of the sewage pumps, which further accelerated the pollution of the water in the dam. Polluted water poses health risks for users and, as a result, deems water unsuitable for human consumption – thus further threatening water security (Fisher-Jeffes et al., 2011; City of Tshwane Metropolitan Municipality, 2020).

In terms of urbanisation, South Africa's urban population stood at 63% in 2011; this is according to the 2011 Census results. It is, however, estimated that South Africa's proportion of urban dwellers could increase to 70% by 2030. These estimates indicate potential and further threats to South Africa's water security (Statistics South Africa, 2020).

Another major factor influencing the availability of water in South Africa is increasing water consumption per capita. Figure 1 illustrates South Africa's potable water withdrawals, i.e. consumption, by sector in 2017 and 2035.

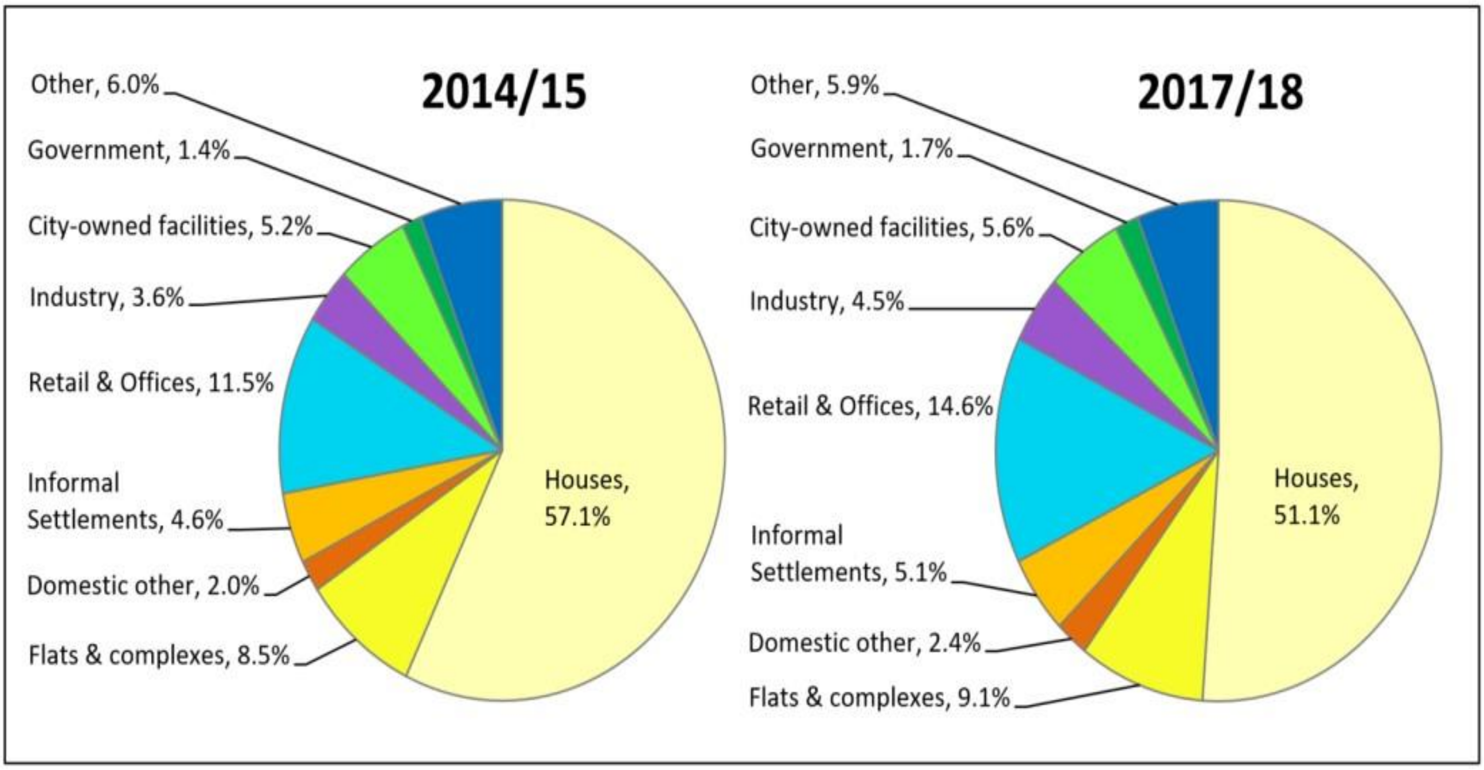
Figure 1: Water withdrawals by sector in South Africa in 2017 (left) and 2035 (right)



(Source: Institute for Security Studies, 2018)

As illustrated in Figure 1, in 2017, a bulk of South Africa's potable water was consumed by the agricultural sector (62.3%). This was followed by the *municipal* sector (27.4%) – which provides water to businesses, institutions, and predominantly urban households – and the *industrial* sector (10.3%). As illustrated, municipal water withdrawals are expected to increase to 31.5% by 2035. Figure 2 illustrates the percentage of *municipal* water used in the City of Cape Town by sector in 2014/15 and 2017/18.

Figure 2: Percentage of municipal water used in the City of Cape Town by sector in 2014/15 and 2017/18



(Source: Sinclair-Smith & Winter, 2018)

Using the City of Cape Town as an example, it is clear that households make up the primary consumers of municipal water. As Figure 2 illustrates, the City of Cape Town's households consumed over 57.1% of municipal water between 2014 and 2015; moreover, this proportion does not account for municipal water consumed in flats and complexes, informal settlements, and other domestic structures. Although the consumption of municipal water by households decreased to 51.1% between 2017 and 2018, which was the same time that the City of Cape Town's day-zero was believed to be imminent, households still consumed a considerable amount of municipal water and still constituted the largest proportion of municipal water consumers.

The City of Cape Town's municipal water consumption decreased during a period of severe water shortages due to the City's simultaneous implementation of strategies to reduce demand. Furthermore, with populations expected to increase, it is important for water managers and service providers to start exploring and implementing ways to manage, and possibly curb, the demand for water by urban households in order to cater for additional users and future inhabitants (Institute for Security Studies, 2018; Sinclair-Smith & Winter, 2018). The numerous ways in which the water demand can be, and in some cases has been, managed or curbed are discussed below.

1.1.4 Approaches for Addressing the Rising Demand for Water

Gilbertson et al. (2011) suggest two approaches for addressing the rising demand for water in cities. These are to:

(a.) *Augment supply*. This refers to supplementing large scale potable water supplies with alternative sources such as groundwater, treated wastewater and sea (salt) water. The latter source is often subjected to the process of purifying salt water into freshwater, which is commonly referred to as desalination. However, the process itself is generally expensive and energy-intensive. Moreover, desalination is mostly applicable to coastal cities (Gilbertson et al., 2011); and/or

(b.) *Reduce Demand*. This refers to reducing the demand for water in urban settings in an effort to dampen the pressure on available water resources. Also known as a 'soft water path', this approach emphasizes water conservation, water reuse and recycling by promoting behavioural change (Gilbertson, et al., 2011).

Various scholars such as Schirmer and Dyer (2018) argue that behavioural change campaigns are more cost-effective when it comes to reducing water consumption, i.e. in comparison to other options such as large scale wastewater treatment plants, desalination, and dam projects (Gilbertson et al., 2011; Schirmer & Dyer, 2018), thus highlighting the suitability of the 'soft water path' approach for contexts that are under economic stress.

Similarly, with global population increases looming and freshwater sources slowly reaching maximum capacity, numerous countries have responded to these challenges by adopting either one or both of these approaches in various ways (Coutts et al., 2012).

For instance, in Tucson Arizona, USA, municipal authorities introduced a series of interventions to reduce water demand at points of consumption, i.e. households, businesses, and institutions. These were introduced in response to the then imminent period of severe water shortages resulting from low rainfall, which averaged at 30mm per annum in the 1970s and depleting groundwater resources. The interventions included tiered water-pricing structures, incentives to assist consumers in investing in water-efficient appliances, new building codes for landscaping to curb water demands for irrigation and encouraging consumers to collect and make use of rainwater to supplement freshwater sources. These were introduced in the early 1980s and have maintained the same consumption levels since they were introduced, despite Tucson's 25% population increase since their introduction (Institute for Security Studies, 2018).

Tokyo, Japan, constitutes another example. In an effort to conserve available freshwater, the installation of dual reticulation systems in urban households was introduced. These systems are designed to allocate and direct saltwater for sanitation purposes and fresh, also known as potable, water for various other domestic uses such as cooking, drinking and showering (Alexander Press, 2018).

In Australia, Water Sensitive Urban Design (WSUD) was introduced in the early 1990s, amongst various other strategies to promote alternative and sustainable stormwater management practices. In addition to managing and curbing the demand for potable water per capita, i.e. by encouraging rain and stormwater harvesting to supplement potable water supplies, the aim of WSUD was to also address the negative impacts of urbanisation and climate change on freshwater resources by using stormwater management practices (Fletcher, et al., 2015).

Traditional stormwater management involves the active conveyance of runoff, i.e. water from precipitation that flows over the surface to the nearest watercourse as quickly as possible (Armitage, et al., 2019; Robertson, et al., 2019). Runoff first flows over artificial surfaces due to urban development and often collects pollutants along the way, which are also transmitted to receiving water bodies, thus threatening their water quality. Furthermore, the presence of impervious artificial surfaces, which are prevalent in urban areas, coupled with extreme weather patterns as a result of climate change, often leads to flooding – which threatens other forms of livelihood such as shelter and, in extreme cases, human life (Armitage et al., 2014; Palafox Jr, 2019; Robertson et al., 2019).

Amongst various other objectives, WSUD aims to address these issues at various scales by promoting impervious surfaces to improve infiltration and thus reduce flooding, as well as green infrastructure to filter out runoff pollutants in an effort to reduce pollution in water bodies. WSUD measures that apply to consumption points such as households include rainwater harvesting, soakaways, green roofs, and permeable paving. In addition to fulfilling the above objectives, these site-scale measures can be applied to manage or curb the demand for potable water by supplementing potable water with alternatives sources such as rain, i.e. precipitation (Donofrio et al., 2009; Armitage et al., 2014; WIN-SA, 2015; Armitage et al., 2019).

Regarding South Africa, several interventions intended to reduce and manage the demand for water at the household level have also been introduced in response to South Africa's water challenges. Amongst these are water conservation (WC) campaigns and Water Demand Management (WDM) strategies. WC describes the minimisation of the loss of water, as well as minimising water wastage (Armitage, et al., 2019; City of Tshwane , 2015). WC also involves the maintenance and protection of water resources, as well as the effective and efficient use of water (Armitage et al., 2014; City of Tshwane, 2015; WIN-SA, 2015).

An example of a WC campaign that has been introduced to South Africans in response to ongoing water challenges is Rand Water's *water wise* campaign. This campaign aims to inform and educate people about the value of water, its resources, and the consequent importance of saving water. Tips on how consumers can save water as part of their daily routine are also provided as part of the campaign (Armitage et al., 2014; City of Tshwane, 2015; Water Wise: Rand Water, 2020; WIN-SA, 2015).

Various WDM strategies have also been widely introduced and implemented across South African municipalities. WDM strategies refer to strategies, policies and/or programmes aimed at reducing the amount of water consumed (Armitage et al., 2014; City of Tshwane, 2015; WIN-SA, 2015). WDM strategies particularly aimed at managing and reducing municipal water demand at the household level are specifically known as municipal water Demand-side Management (DSM) instruments (Renwick & Green, 2000; Inman & Jeffrey, 2006). Traditional DSM instruments include water tariff structures such as tiered pricing; various water use regulation mechanisms such as building codes, municipal by-laws and water use restrictions; informative billing; and incentive schemes, amongst others. Incentive schemes can manifest in the form of municipal service tax breaks (tax incentives) and assistance, usually by authorities, to install water-efficient appliances, devices and technologies (Renwick & Green, 2000; Inman & Jeffrey, 2006; Armitage et al., 2014).

The City of Cape Town, as noted earlier, made use of various municipal water DSM instruments to assist residents, and businesses alike, in terms of adhering to stringent water allocations as a result of limited supply. Among the instruments applied and implemented by the City of Cape Town were high water tariffs for consumers exceeding the allocated daily limit and water use restrictions, otherwise described as prohibitions on selected non-essential and heavy water use activities; for example, the filling up of swimming pools and garden irrigation. (Institute for Security Studies, 2018; Sinclair-Smith & Winter, 2018; Palafox Jr, 2019).

Both WC and WDM are effective in reducing the demand for municipal potable water at the household level. The City of Cape Town serves as an example of how these strategies can help curb potable water demand. However, tightly constrained water supplies still have the potential to result in unmet basic needs, continued water quality deterioration, as well as the resulting negative environmental consequences. Furthermore, although high water tariffs can reduce potable water consumption, given South Africa's current economic climate, this would however further burden citizens. Moreover, there is no guarantee that most consumers would be able to honour relatively higher water bills, i.e. unless strict enforcement measures are also put in place.

Consequently, there is a need to explore various other solutions in response to the country's current water challenges. One such solution is the concept of WSUD, as outlined earlier. The potential for WSUD to effectively address the country's challenges with water is asserted by Toxopeus (2019) in her three (3) part study titled *Developing Water Sensitive Cities in South Africa*:

> "Recent water shortages in major economic hubs and water restrictions implemented across the country have illustrated the need to diversify the mechanisms used to deliver water to urban areas. WSUD provides an alternative which could be integrated into the management mix to provide a hybrid system of water delivery"(Toxopeus (a.), 2019, online source)

Furthermore, the 2014 publication of South Africa's first WSUD Framework and Guidelines by the Water Research Commission (WRC) indicates a growing interest in WSUD as a potential response to the water challenges facing the country. The subsequent section examines the notion of WSUD in detail.

1.2 Conceptualising Water Sensitive Urban Design

This section outlines the definition of WSUD, its premise, and the relevant applications (or measures) and benefits. Furthermore, the relationship between WSUD and urban planning and its institutional setting in South Africa are also discussed.

1.2.1 Defining Water Sensitive Urban Design

1.2.1.1 The Origins of Water Sensitive Urban Design

Australians first used the term Water Sensitive Urban Design in the 1990s; it was used in response to challenges relating to urban drainage, also known as stormwater management and water quality. Therefore, WSUD was initially used as an approach to manage stormwater in urban areas. The key objectives of WSUD were then to minimise flooding as well as the pollution of water bodies by minimising stormwater runoff and treating runoff pollutants by using various development measures and technologies; such as permeable surfaces, wetlands, as well as retention and detention ponds (Armitage et al., 2014; Fletcher et al., 2015).

However, with the introduction of the concept of Water Sensitive Cities (WSCs) by Brown et al. (2008) at the 11th International Conference on Urban Drainage, the concept of WSUD was expanded from a stormwater management approach to an approach designed to manage all water-related aspects in an urban setting (Armitage et al., 2014; Fletcher et al., 2015).

A WSC is a city where “water is given due prominence in the [planning and] design of urban areas” (Armitage et al., 2014, p. 3).

Rohr et al. (2017) define a WSC more comprehensively as:

> “…a city [that] serves as a potential water supply catchment, providing a range of different water sources at a range of different scales, and for a range of different uses; [a city that] provides ecosystem services and a healthy natural environment, thereby offering a range of social, ecological and economic benefits; and consist[s] of water sensitive communities

> where citizens have the knowledge and desire to make wise choices about water, [are] actively engaged in decision-making and demonstrate positive behaviours such as conserving water at home…" (Rohr et al., 2017, p. 14)

As such, WSUD was proposed as a tool or framework within the broader urban setting to help realise the objectives of a WSC (Armitage et al., 2014; Rohr et al., 2017). As a result, the original concept for WSUD was extended to encompass the sustainable management of additional streams of the urban water cycle – which in addition to stormwater include potable water, groundwater, and wastewater – as well as the planning and design of urban developments (Donofrio et al., 2009; Armitage et al., 2014; Fletcher et al., 2015).

According to Armitage et al. (2014), the WSUD approach has advanced from just considering stormwater as a supplementary source of water to an approach that also assesses "whether other municipal functions, such as urban drainage and planning, wetland conservation, WDM and wastewater reuse could augment water security in the face of increasing and multiple demands through enhanced coordination and integration" (Armitage et al., 2014, p. 40). As such, the current definition for WSUD is discussed in the subsequent section.

1.2.1.2 Defining Water Sensitive Urban Design

A wide variety of definitions for WSUD are available in the existing body of knowledge. Several examples are provided below:

> "WSUD…defined as integrating urban planning and design with the urban water cycle" (Palafox Jr, 2019, online source)

> "WSUD is understood…as…an approach to urban planning and design that integrates land and water planning and management into urban design. WSUD is based on the premise that urban development and redevelopment must address the sustainability of water." (Armitage et al., 2014, p. 16)

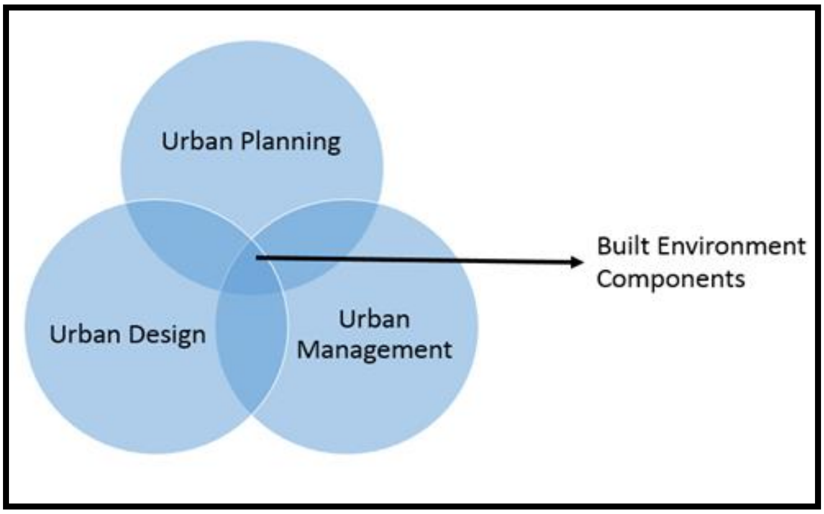
> “WSUD…the integration of urban planning with the management, protection and conservation of the urban water cycle, that ensures urban water management is sensitive to natural hydrological and ecological processes” (Coutts et al., 2012, p. 5)

> “Lloyd et al. (2002, p. 2) describe WSUD as a philosophical approach to urban planning and design that aims to minimise the hydrological impacts of urban development on the surrounding environment. Stormwater management is a subset of WSUD directed at providing flood control, flow management, water quality improvements and opportunities to harvest stormwater to supplement mains water for non-potable uses” (Fletcher et al., 2015, p. 528)

Therefore, for the purposes of this study, WSUD is defined as an *integrated* and *multi-disciplinary* approach to urban planning that integrates urban planning, design and development with the management of the urban water cycle (ESI Africa, 1997; Brown et al., 2008; Coutts et al., 2012; Armitage et al., 2014; Fletcher et al., 2015; WIN-SA, 2015; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019; Palafox Jr, 2019; Toxopeus (a.), 2019). In practical terms, WSUD integrates urban planning and design with the provision of infrastructure for water supply, sanitation, wastewater, stormwater, and groundwater (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

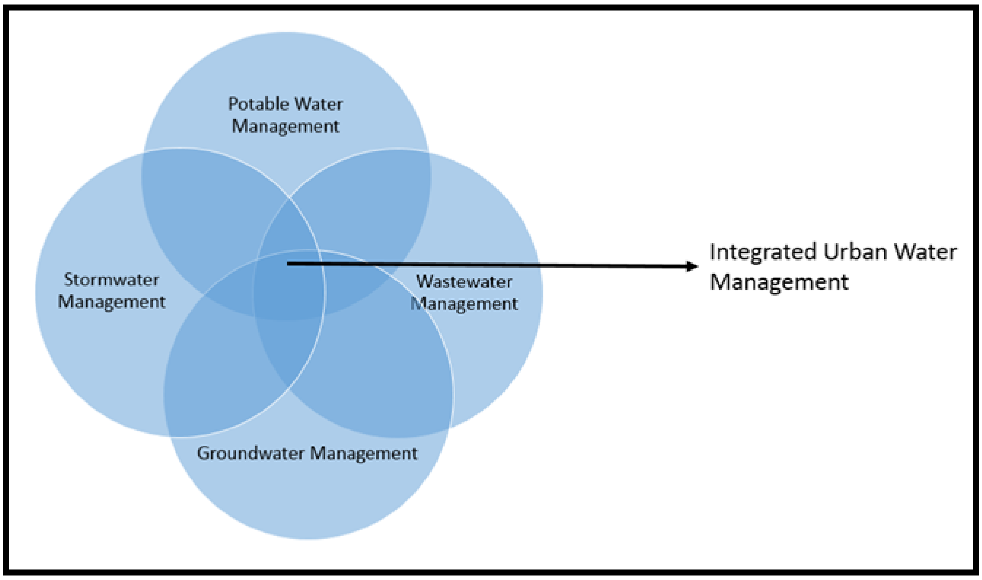
WSUD thus involves integrates two components, i.e. the *built environment* component and the *urban water management* component. Figure 3 illustrates the components of the built environment.

Figure 3: Components of the Built Environment



As illustrated in Figure 3, the built environment components consist of urban planning, urban design, and urban management. The mechanisms of an integrated urban water management approach are illustrated in Figure 4 below.

Figure 4: An illustration of an Integrated Urban Water Management approach



As Figure 4 illustrates, when all streams of the urban water cycle - i.e. potable water, stormwater, wastewater, and groundwater - are managed holistically, integrated urban water management is maintained. As highlighted by the various definitions for WSUD, an approach to WSUD encompasses the integration of an already integrated urban water management process, i.e. whereby all streams of the urban water cycle are amalgamated and continuously managed holistically, into the practice of planning, developing and managing urban areas (ESI Africa, 1997; Brown et al., 2008; Coutts et al., 2012; Armitage et al., 2014; Fletcher et al., 2015; WIN-SA, 2015; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019; Palafox Jr, 2019; Toxopeus (a.), 2019). This *integrated* attribute of WSUD informs another key aspect of WSUD, which is its *multi-disciplinary* disposition.

As discussed, WSUD involves the simultaneous management of the integrated urban water cycle and the planning, design, and management of urban areas. As such, the implementation of WSUD requires the holistic collaboration of disciplines. These [disciplines] include urban planning, urban design, architecture, environmental sciences, municipal management, engineering, hydrology, property development, construction, as well as environmental sociology and psychology, amongst others (Armitage et al., 2014; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

The association between WSUD and Sustainable Development are discussed in below.

1.2.1.3 Water Sensitive Urban Design and Sustainable Development

Through its desired outcome of realising WSCs, WSUD is often understood as a medium through which Ecological Sustainable Development (ESD), which involves the conservation and protection of natural resources in addition to the protection of the environment from the effect of pollutions – is realised (Armitage et al., 2014; Beza et al., 2018). Moreover, and as a result of its desired outcome of WSCs, several Sustainable Development Goals (SDGs), which have been introduced to advance the principles of sustainable development, draw attention to some of the fundamental aspects of WSUD. Examples of such SDGs, as extracted from the United Nation’s (UN) official list of SDG indicators, are outlined below:

- *“By 2030, improve water quality by reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally”* (United Nations, 2016, p. 9 of 25)

- *"Support and strengthen the participation of local communities in improving water and sanitation management"* (United Nations, 2016, p. 9 of 25)

- *"By 2030, enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries"* (United Nations, 2016, p. 14 of 25)

- *"By 2030, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels"* (United Nations, 2016, p. 15 of 25)

The details outlined in the applicable SDGs are accentuated in the aim and objectives of WSUD, which are discussed in the subsequent section.

1.2.2 The Aim, Objectives and Benefits of Water Sensitive Urban Design

1.2.2.1 The Aim and Objectives of Water Sensitive Urban Design

WSUD aims to minimise the negative impacts of urban development on the environment (particularly the hydrological aspects of the environment), as well as to enhance the sustainability of water; i.e. by imitating, as far as possible, the natural water cycle (also known as the process of maintaining the water balance) when planning and designing a neighbourhood, city, or settlement (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019; Climate ADAPT, 2020).

The natural process of maintaining the natural water balance, or the natural water cycle, involves the following phases:

- ***Phase 1*** *Evaporation*: This is where the dome of the surface water (i.e. in the form of droplets) changes from liquid to gas, which is known as water vapour;

- ***Phase 2 Condensation***: This is where water vapour rises into the atmosphere, cools down, then changes from a gas to a liquid (droplets);

- ***Phase 3 Precipitation***: This is where water droplets join together to form clouds, which eventually become too heavy to stay in the atmosphere; these then fall to earth as rain, hail, and snow;

- ***Phase 4a Infiltration***: This is where some droplets fall to the ground and seep through the surface to recharge groundwater;

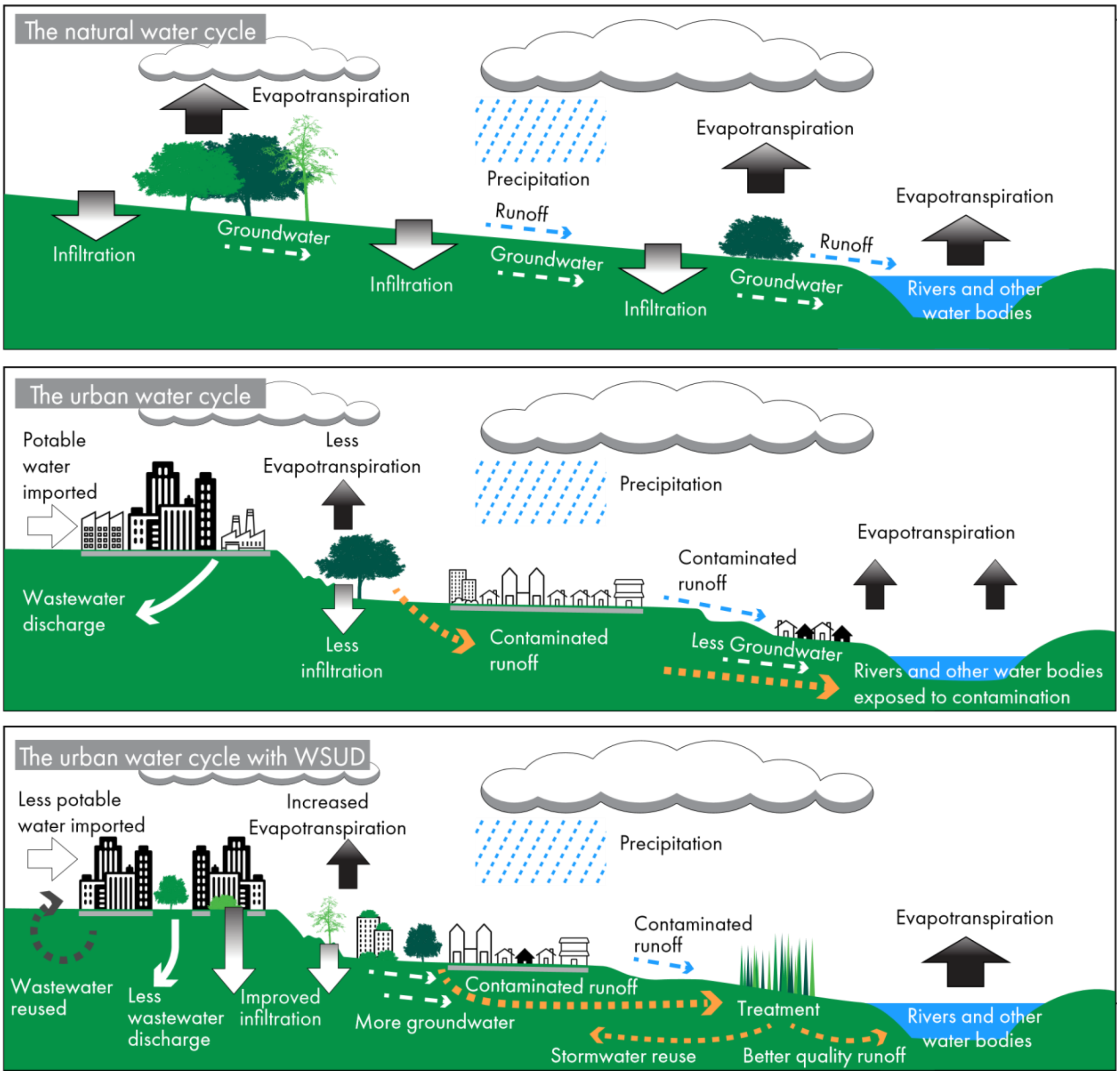
- ***Phase 4b Runoff***: This is where some droplets flow over the surface and into receiving water bodies; and

- ***Phase 4c Surface Water Recharge***: This is where the rest of the droplets fall into surface water bodies, i.e. rivers, dams, streams, lakes, and the ocean.

(Council for the Scientific and Industrial Research; Department of Human Settlements, 2019; Water Wise: Rand Water, 2020)

However, urban developments – particularly as a result of conventional urban water systems that are designed to source, treat, transport, and distribute potable water, then collect, treat and dispose of the consequent wastewater that is produced – alter the natural water cycle (Armitage et al., 2014; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019; Water Wise: Rand Water, 2020). Figure 5 indicates the state of the water cycle under different conditions.

Figure 5: The water cycle under different conditions



(Source: Council for the Scientific and Industrial Research; Department of Human Settlements, 2019)

As indicated in Figure 5, and with regards to the urban water cycle, wastewater is generated that needs to be discharged somewhere and, evapotranspiration – which consists of both evaporation and plant transpiration - is inhibited as a result of high densities and minimal vegetation, which characterises urban areas (U.S. Department of the Interior, 1973; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019). Moreover, as a result of hard surfaces covering a substantial part of the urban area, i.e. buildings, roads, and concrete pavements – the infiltration of water (i.e. precipitation) into the ground is reduced, while the volume of runoff – which is often of poor quality as a result of pollutants found on artificial surfaces – increases (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

As a result, WSUD aims to minimise the negative impacts imposed by development on the natural water cycle by achieving the following objectives:

a. **Protecting the natural environment**: WSUD seeks to protect water resources from pollution, erosion and degradation while consequently improving their support functions for other natural inhabitants, thus enhancing biodiversity (Donofrio et al., 2009; Sharma et al., 2016).

b. **To achieve water balance**: as discussed earlier, WSUD also aims to imitate the natural or predevelopment process of maintaining the water balance by imitating the predevelopment hydrological process (Vernon & Tiwari, 2009; Sharma et al., 2016).

c. **To Improve water quality**: WSUD seeks to improve the quality of ground and surface water resources through the exploitation of various green infrastructure and technologies that are designed to filter out or treat groundwater and runoff pollutants as well as promote infiltration (Vernon & Tiwari, 2009; Carmon & Shamir, 2010; Sharma et al., 2016).

d. **To reduce portable [fresh] water consumption**: WSUD seeks to reduce the demand, as well as the consequent consumption of freshwater by introducing and encouraging the use of alternative sources of water in a fit-for-purpose manner (Donofrio et al., 2009; Vernon & Tiwari, 2009; Sharma et al., 2016).

e. **To mitigate floods**: WSUD aims to mitigate floods by reducing runoff volumes through the employment of sustainable urban drainage measures with effective runoff treatment and conveyance, as well as infiltration qualities such as porous surfaces (Donofrio, et al., 2009; Vernon & Tiwari, 2009; Carmon & Shamir, 2010; Sharma, et al., 2016).

f. **To achieve landscape amenity**: WSUD also aims to achieve landscape amenity through the application of dual-function measures such as bio-retention systems and constructed wetlands (amongst many others) – both of which include the functions of sustainable drainage, biodiversity protection as well as site or area beautification, i.e. amenity (Donofrio et al., 2009; Vernon & Tiwari, 2009; Carmon & Shamir, 2010).

1.2.2.2 Benefits of Water Sensitive Urban Design

Consequently, by realising the identified aim and objectives, WSUD may well yield numerous benefits for the environment and society. Hence, when implemented accordingly, WSUD offers some economic, social and environmental benefits. These are outlined in Table 1 below.

Table 1: Benefits of Water Sensitive Urban Design

Type of Benefit	Description
Economic	• Job creation, i.e. as a result of the introduction of new technologies that have the potential to be commercialised. • Reduction in water tariffs and related water service costs resulting from the use of cost-efficient, sustainable and alternative water sources to supplement potable supplies.
Social	• Improved social equity as a result of improved access to diversified water resources. • Improved water security. • Social awareness and behaviour change towards more sensitive use of water.

Table 1: Benefits of Water Sensitive Urban Design

Type of Benefit	Description
Environmental	• Improved human thermal comfort as a result of increased investment in green infrastructure. • Soil moisture replenishment as a result of infiltration. • Water pollution management and reduction. • Increased resilience to climate change and extreme weather conditions (i.e. natural disasters such as floods). • Enhanced biodiversity. • Increased Sustainability.

References: Coutts et al. (2012); Armitage et al. (2014); Fletcher et al.(2015) and Rohr et al. (2017)

1.2.3 *Water Sensitive Urban Design Strategies and Interventions*

This subsection of the report identifies the strategies, as organised according to the applicable urban water cycle streams, for implementing WSUD. These include sustainable urban drainage systems (SUDS), appropriate sanitation and wastewater systems, groundwater management, and sustainable water supply.

1.2.3.1 Sustainable Urban Drainage Systems

Also known as Sustainable Drainage Systems (SuDS) – SUDS represent an alternative approach to stormwater management. SUDS involves a network of technologies and measures designed to control stormwater runoff volume and velocity; improve ground and surface water quality by treating runoff; enhance biodiversity by improving the ecological support functions of receiving water bodies, and enhance amenity qualities by forming part of an area’s natural open space network, i.e. in addition to contributing to the area’s environment and neighbourhood character (Fletcher et al., 2015; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019). SUDS measures and technologies include the following:

- **Source controls** – which are used to control or manage stormwater as close to the source as possible, i.e. within the boundaries of a property (Armitage et al., 2014; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Local controls** – which are used to control or manage stormwater locally, i.e. within a road reserve (Armitage et al., 2014; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Regional controls** – which manage runoff that is collected from several developments (Armitage, et al., 2014; Armitage, et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

Table 2 provides a comprehensive list of SUDS measures and technologies and the relevant scale(s) of application.

Table 2: Sustainable Urban Drainage Systems measures and technologies by application scale

Scale	SUDS measures and technologies
Source Controls	• Green roofs • Rainwater harvesting • Soakaways • Permeable paving

Table 2: Sustainable Urban Drainage Systems measures and technologies by application scale

Scale	SUDS measures and technologies
Local Controls	• Filter strips • Swales • Infiltration trenches • Bio-retention areas • Sand filters
Regional Controls	• Detention ponds • Retention ponds • Constructed wetlands

Reference: Council for the Scientific and Industrial Research; Department of Human Settlements (2019)

SUDS *source controls* are mainly applicable at the household or domestic plot level. As illustrated in Table 2, these source controls or measures include green roofs, soakaway(s), permeable paving, as well as rainwater harvesting. Local controls include filter strips, swales, infiltration trenches, bio-retention areas and sand filters. Regional controls include detention ponds, retention ponds, and constructed wetlands (Armitage et al., 2014; Armitage, et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

However, although the various SUDS measures are usually associated with the relevant scales of application, it is possible to take up the measures elsewhere, i.e. at other scales, depending on the site. For instance, although constructed wetlands and retention and detention ponds are generally regarded as regional controls, they can also be taken up as source controls, i.e. at the household level. A pocket wetland in a residential complex constitutes an example (Armitage, et al., 2019).

1.2.3.2 Appropriate Sanitation and Wastewater Systems

The purpose of this strategy is to promote the effective and efficient use of water. It consists of various measures and technologies intended to reduce water use, allow for the use of treated wastewater, and minimise wastewater (Council for the Scientific and Industrial

Research; Department of Human Settlements, 2019). Regional and local scale measures include wastewater treatment plants, as well as septic tank systems; while site, or rather household appropriate measures include aerobic treatments and compost toilets (Coutts et al., 2012; Lottering et al., 2015; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

One notable site-scale or household appropriate measure regarding wastewater as a resource is greywater reuse (Armitage et al., 2014; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019). However, greywater reuse is regarded as a supplementary potable water resource, particularly if and when it is used in a fit-for-purpose manner. The term *fit-for-purpose* acknowledges that varying uses of water do not require the same level of water quality (Armitage, et al., 2019; Lottering, et al., 2015; Rohr, et al., 2017). As such, greywater may be used in a fit-for-purpose manner to supplement potable water supplies for non-potable uses such as toilet flushing, as well as garden and lawn irrigation (ESI Africa, 1997; Coutts et al., 2012; Armitage et al., 2014; Lottering et al., 2015; Rohr et al., 2017).

1.2.3.3 Groundwater Management

The premise behind this strategy is to regard groundwater as an alternative water supply resource and thus aims to conserve and protect groundwater resources while promoting artificial recharge measures and technologies, where suitable. A constructed wetland is an example of an artificial regional-scale groundwater management measure or technology. When it comes to households or site-scale appropriate measures – permeable paving features as a prevalent measure (Armitage et al., 2014; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

1.2.3.4 Sustainable Water Supply

This strategy seeks to improve the efficient use of water and reduce the demand for potable water. This strategy's proposed tactics include WC, WDM, as well as the use of alternative water sources to supplement potable water supplies, i.e. rainwater, stormwater, greywater and groundwater (Armitage et al., 2014; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019). In terms of measures, rainwater harvesting and greywater reuse emerge as feasible measures to take up or implement at the household level (Armitage et al., 2014; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

1.2.4 Water Sensitive Urban Design Measures for Urban Households

This section of the report identifies the various WSUD measures, as summarised from the strategies above, that can be adopted or "taken up" at site-scale, or rather household level. These include green roofing, rainwater harvesting, permeable paving, soakaway(s), and greywater reuse. Moreover, the advantages and disadvantages associated with each of the measures are outlined below.

1.2.4.1 Rainwater Harvesting

Rainwater harvesting refers to the direct capture of rainwater, typically from roofs, for supplementary use. Rainwater can be collected directly from the source into buckets, containers and harvesting tanks or building roofs through gutters and into tanks (Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Advantages** – Rainwater harvesting reduces potable water consumption, runoff volumes and flooding (Armitage, et al., 2014; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Disadvantages** – Rainwater harvesting is an ineffective water supply resource for hot and dry areas; moreover, rainwater harvesting tanks are relatively expensive and rainwater is often unsuitable for direct human consumption unless expensive technologies are used to filter out pollutants (Armitage, et al., 2014; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

1.2.4.2 Green Roofs

A green roof refers to a roof that is covered in vegetation. Green roofs provide numerous benefits for highly dense urban areas where there is relatively less space for implementing other WSUD measures (Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Advantages** – Green roofs are feasible in both brownfield and greenfield developments; green roofs improve surrounding air quality, enhance biodiversity and improve local amenity; green roofs also regulate building temperatures by providing insulation, and as a consequence, reduce energy costs (Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Disadvantages –** Green roofs require plant experts and water-proofing professionals; they are relatively expensive to implement instead of conventional roofs, and could result in leakages (Stahre, 2006; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

1.2.4.3 Permeable Paving

Permeable paving refers to surfaces or pavements constructed to promote the infiltration of runoff through the surface and into the ground. Examples include lawn (grass), gravel, stone chips, brick pavers, concrete block pavers, as well as porous concrete and asphalt (Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Advantages** – Permeable paving reduces stormwater runoff volumes; permeable paving increases the area (m^2) on specified developments deemed useable for urban drainage; and improves groundwater recharge (Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Disadvantages** – Permeable paving is not suitable for areas with high traffic volumes and speeds. These usually have the lowest pollutant removal capacity compared to other SUDS volumes (Woods-Ballard, et al., 2007; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

1.2.4.4 Soakaways

A soakaway is an underground storage area filled with course and porous media, such as rocks, that discharges stormwater (and in some cases greywater) gradually into the soil as well as receiving groundwater resources (Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Advantages** – Soakaways decrease runoff volumes and velocities significantly; soakaways have effective pollutant removal capacities (Stahre, 2006; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Disadvantages** – Soakaways are not suitable for steep slopes and unstable areas, i.e. dolomitic areas (Woods-Ballard, et al., 2007; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

1.2.4.5 *Greywater Reuse*

Greywater reuse refers to the use of greywater for non-potable water uses, while greywater refers to untreated wastewater that is generated from domestic activities, i.e. excluding toilet flushing. As such, greywater can be generated from baths, showers, sinks, and dishwashing machines. However, activities that have the potential to contaminate water with harmful pathogens, such as baby and nappy washing, are not regarded as sources of greywater (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019). Greywater reuse instruments include buckets or containers, which can be used to collect and convey greywater for reuse; as well as greywater reuse systems such as a greywater diversion device, which is commonly used for subsurface irrigation, and a greywater treatment system, which can be used for toilet flushing and irrigation (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Advantages –** Manual greywater reuse, i.e. buckets, is technically feasible; and it is estimated that an average of 30% of potable water is used for flushing, i.e. in urban households. Therefore, the use of greywater for non-potable uses such as flushing presents urban households with an opportunity to reduce almost a third of their average potable water consumption (Coutts et al., 2012; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

- **Disadvantages** – The reuse of greywater may be socially unacceptable due to inherent health, odour and aesthetic concerns (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

The subsequent section discusses the association between Water Sensitive Urban Design and urban planning.

1.3 Water Sensitive Urban Design and Urban Planning

This section outlines the role of WSUD in urban planning. As noted earlier, WSUD is an urban planning approach. This approach requires the natural water cycle, as outlined earlier, to be given 'due prominence' when it comes to planning, designing, developing and managing urban areas (Armitage et al., 2014; Toxopeus (a.), 2019). The purpose of the WSUD approach is to "minimise the negative impact of urban development on the environment and to enhance the sustainability of water" (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019, p. L.7).

Although identified by many as an approach to urban planning, the notion of WSUD also encompasses technical aspects of urban design, landscape architecture, transport planning (i.e. through stormwater management) as well as water resource management (amongst various other disciplines). In particular, WSUD typically manifests itself, or rather finds practical expression in the sustainable management of stormwater (i.e. through the implementation of various SUDS controls such as rainwater harvesting), the fit-for-purpose reuse of greywater, as well as through the greening of the urban environment (i.e. through the construction and conservation of wetlands, detention and retention ponds, bioswales, as well as rain gardens, to name a few) (Armitage, et al., 2019; Toxopeus (a.), 2019).

WSUD also signifies a paradigm shift towards the planning and design of urban environments. This 'shift' compels urban planners and designers to be 'water sensitive' (Armitage et al., 2014). Armitage et al. (2014) define the term 'water sensitive' in terms of South Africa's water context as:

> "…[the] management of water, bearing in mind that 1) South Africa is a water-scarce country; 2) access to water is a basic human right; 3) water is an economic good; 4) water management should be based on a particular approach; and 5) water is a finite and vulnerable resource" (Armitage et al., 2014, p. 27)

Therefore, by considering the above details when undertaking planning and designing efforts for areas in the country, water sensitive planning is thus achieved, particularly in the context of South Africa.

The general purpose of urban planning is to guide future development; it deals with the organisation of urban features (or structuring elements) and activities. Moreover, urban planning involves the predetermination and the drafting of plans (and layouts) for future physical arrangements of the features and activities (Schneider et al., 1973; Armitage et al., 2014). However, when it comes to 'water sensitive' planning (WSP), or rather 'water sensitive' urban planning, the following process applies:

- **Step 1**: An area or urban water catchment is considered, i.e. subject area.
- **Step 2**: Factors and possible changes in each area or catchment are considered.
- **Step 3**: How each factor or change could or should direct development is then considered.
- **Step 4**: The implications of the determined direction of future development on water resources are considered.
- **Step 5**: Resolutions to mitigate the identified negative effects of future development on water resources are considered and, provision thereof is made.

(Armitage, et al., 2014)

Several urban planning components and tools can be used to facilitate water sensitive planning and implement WSUD. Spatial modelling and spatial analysis are some of them. For instance, Rohr et al. (2017) suggest what they refer to as *systematic biodiversity planning*. This involves the spatial analysis of water use data from various sectors, such as households (which are of particular importance to this study), businesses and institutions, to identify water-intensive sectors across various areas, thus highlighting the importance of a study like this for urban planning. Rohr et al. (2017) further suggest the spatial targeting of the sectors identified as water-intensive across various areas, i.e. in an effort to target the identified areas for the appropriate uptake of WSUD measures to curb water use (Rohr et al., 2017). For example, if inner-city businesses are identified as water-intensive – they would then be presented with an opportunity (or requirement) to reuse greywater for non-potable uses such as toilet flushing and would thus be targeted for fit-for-purpose greywater reuse (Rohr et al., 2017).

Additionally, WSUD measures such as greywater reuse and rainwater harvesting can be enforced through building codes (Rohr et al., 2017). However, compliance with building codes is often evaluated by architects. Nevertheless, planners can still participate by identifying water constrained or wasteful water areas and require proposed developments, through the development application process, within the identified areas to comply with the relevant WSUD-related regulations (or requirements) outlined in the building codes (Rohr, et al., 2017). Planners could also employ land use management tools such as development controls for new developments in an effort to promote and support the uptake of several WSUD measures. For instance, in an effort to promote the uptake of RWH, standardized roof materials as well as a minimum roof area (m^2) could be included in town planning schemes and mandated wherever necessary, as rainwater yields are relatively dependent on these factors (Fourie, et al., 2020).

Lastly, when features such as waterways, water bodies, and various WSUD measures (also referred to as water infrastructure) are identified and appropriately arranged as key structural elements in urban plan(s); various WSUD benefits are produced in the subject urban settings. For instance, by integrating these 'elements' into broader urban plans or layouts – existing open space networks can be supported, and the local character of targeted areas can be enhanced. Moreover, these WSUD-related elements can provide amenity; i.e. while simultaneously fulfilling the primary objectives of WSUD (Beza et al., 2018).

Therefore, WSUD has a fundamental role in planning urban developments, or more specifically 'water sensitive' habitats, i.e. WSCs. As suggested, various planning tools can be utilised to facilitate WSUD. Moreover, when applied tactically, these tools can be translated into structured planning interventions, also known as best planning practices (BPPs). On the other hand, although the term 'urban design' is included in phrase 'water sensitive *urban design*' (***emphasis mine***), its implication to the approach is not necessarily literal. The urban design discipline deals mainly with the local design (or form) of an area that fits into existing urban plans. It involves the design and, to some extent, arrangement of (often individualized) buildings, transport systems, services, public open spaces and amenities (Armitage et al., 2014). Elrahman and Asaad (2021) provide the following definition of urban design:

> "Urban design…[is] defined as; a bridge between architecture and urban planning; a multidisciplinary, complex process confining more than

architecture and planning only; *a relationship between built and unbuilt space*. It [is] defined also as the art and qualities of city form; the art of making better spaces for people and public life; a way of thinking…[as well as the design of] *spaces between buildings*" (Elrahman & Asaad, 2021, p. 1163; ***emphasis mine***)

Rowley (1994) simplifies the term by defining urban design as the practice of place making, where places are perceived and designed as not just specific spaces, but also all the activities and events that make them possible (Rowley, 1994). Therefore, similar to disciplines such as urban planning and landscape architecture, practical aspects of urban design such as the design of streetscapes and interfaces (e.g. through the provision of permeable pavements, roadside swales and infiltration trenches) give practical expression to the notion of WSUD.

The various institutional and legislative provisions made for WSUD, in the South African context, are discussed in the subsequent section.

1.4 Water Sensitive Urban Design in South Africa

The purpose of this section is to examine the status quo of WSUD in South Africa by outlining the various institutional and legislative arrangements that have been established to enable the implementation of WSUD in South Africa.

According to South Africa's constitution, the regulation for *Municipal Planning*, *Stormwater Management*, and *Water and Sanitation* services – which constitute the key components of WSUD – is the responsibility of local governments. However, the same constitution mandates both the national and provincial governments to strengthen and support the relevant local governments in order to enable them to effectively execute their functions and manage their affairs (Toxopeus (a.), 2019; Toxopeus (b.), 2019). As such, various national and local policies (and legislation) relating to WSUD, or components thereof, are discussed.

To date, various national policies have been introduced to guide the implementation of WSUD in South Africa. These include the 2014 *WSUD Framework and Guidelines for South Africa*, the Council for Scientific and Industrial Research's (CSIR's) *Neighbourhood Planning and Design Guidelines* – which provide specific guidelines on implementing and constructing various WSUD measures and technologies, as well as the recently published *South African*

Guidelines for Sustainable Drainage Systems (Armitage et al., 2014; Armitage et al., 2019; Council for the Scientific and Industrial Research; Department of Human Settlements, 2019).

Notably, various concepts related to WSUD have been amended to adapt to the country's context. For instance, WSUD is also referred to as Water Sensitive Design (WSD); this amendment was done to acknowledge the fact that the WSUD approach can be applied to settlements in general and that it is not limited to areas in urban settings (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019). The same has been done to the concept of WSCs; which has been revised to *Water Sensitive Settlements* (WSSs) to make provision for the WSUD approach to be applied to other areas, such as rural areas and informal settlements i.e. in addition to urbanised ones. The *WSUD for South Africa* framework defines WSSs as:

> "…a settlement where the management of the urban water cycle is undertaken in a 'water sensitive' manner; using the philosophy of WSUD – with the overall objective being [an] ESD [Ecological Sustainable Development]." (Armitage et al., 2014, p. 8)

The *National Climate Change Response White Paper* is another noteworthy policy. It highlights various aspects of WSUD. For instance, the minimisation of pollution and the sustainable and efficient capture of water in the urban landscape – which is synonymous with the objectives of WSUD – is suggested. Furthermore, the White Paper obligates urban [infrastructure] planning processes to take water supply constraints and extreme weather events, such as floods and droughts, into account (Toxopeus (b.), 2019).

Various other national legislation related to urban water management partly resonate with some objectives and intentions of WSUD. However, one that encompasses all components of WSUD comprehensively and makes provisions for its enforcement – is yet to be promulgated. For instance, schedule 1 (1_a) of the 1998 *National Water Act* (NWA) allows for the use and collection of runoff from roofs – which essentially describes rainwater harvesting (Armitage et al., 2014). Furthermore, the NWA – among other things – aspires to ensure that the country's water resources are protected, as well as used and managed in a sustainable manner (Armitage et al., 2014). Therefore, besides its endorsement for rainwater harvesting, no other primary WSUD measures are specifically encouraged in the 1998 NWA (Department of Energy, 1998; Department of Water Affairs: RSA, 2020).

The *second National Water Resource Strategy* (NWRS-2) – which was drafted in response to South Africa's *National Development Plan: Vision 2030* – guides the management and future development of the country's water infrastructure. The strategy is shaped by the principles of *equity*, *efficiency* and *environmental sustainability*. Furthermore, it highlights the need to incorporate alternative water sources into bulk potable water supplies and features a national water reuse strategy for the centralised effluent treatment (i.e. wastewater). Though aspects of this strategy resonate with some of the key aspects of WSUD, it does not adequately provide for the integrated management of the urban water cycle, i.e. integrated urban water management (National Planning Commission, 2011; Department of Water and Sanitation, 2013; Armitage et al., 2014).

In terms of local institutional arrangements – the City of Cape Town is at the forefront of promoting and implementing WSUD and transitioning towards a WSC. This is demonstrated by the City of Cape Town's *Water Strategy*, which commits to guiding the City's transition towards a WSC. Moreover, to facilitate and integrate the management of all streams of the urban water cycle, the City of Cape Town Metropolitan Municipality has recently transferred all functions related to stormwater management from the former Roads and Stormwater department to its Water department. Furthermore, the City's *Stormwater Management By-Law*, which is believed to be the most advanced piece of local stormwater management policy in the country, mandates stormwater runoff treatment before conveying it to receiving water bodies (Toxopeus (c.), 2019; Armitage et al., 2014).

Similarly, the City of Cape Town's planning legislation has also managed to incorporate various aspects of the WSUD approach. For instance, the City's *Spatial Development Framework* highlights the need to maintain a balance between urban development and environmental protection. It further instructs the need to take the sustainability and protection of both water and biodiversity into account when planning. Furthermore, the City of Cape Town has developed a *Stormwater Management Impacts Policy*, aiming to minimise stormwater runoff impacts in the City. The policy introduces best management practice (BMP), similar to BPP, to achieve the objectives of SUDS in various development scenarios (Toxopeus (c.), 2019). Consequently, it requires all stormwater management systems to be planned and designed according to the criteria (Toxopeus (c.), 2019). Therefore, the inclusion of dwelling units, or households, as one of the development scenarios could enable households to participate in the implementation of WSUD through SUDS in the City of Cape Town (Toxopeus (c.), 2019).

Likewise, the City of Johannesburg has also attempted to integrate aspects of the WSUD approach into its policy framework. For instance, the City of Johannesburg's long-term

Growth and Development Strategy aims to integrate the urban water cycle into its water management system. The strategy aims to promote localised opportunities to save water by developing various mechanisms to help reduce the contamination of surface water resources and conserve water resources (Toxopeus (c.), 2019). These 'localised' opportunities could enable households to participate in the City's efforts to protect the quality and quantity of water, and the implementation of WSUD, as a consequence (Toxopeus (c.), 2019).

The City of Johannesburg's *Climate Change Adaptation Plan* constitutes another policy of interest. The plan identifies the contamination of stormwater runoff as a threat to water quality and emphasizes the need to adopt 'adequate' stormwater infrastructure. Furthermore, the plan suggests the inclusion of permeable pavements in open spaces in an effort to minimise urban flooding (Toxopeus (c.), 2019).

Therefore, as indicated by the summary above, it can be argued that, to some extent, institutional and legislative arrangements have been established to integrate the WSUD approach into South Africa's planning and development context. Various guidelines and policies promote the implementation of various WSUD measures in response to the current water challenges facing the country. However, the legislative context needs to be expanded to regulate, enforce, and normalise what is suggested by the various policies, as discussed above. This could help accelerate the implementation of WSUD in South Africa and consequently address the current water challenges facing the country.

Moreover, as highlighted earlier, households consume a considerate amount of municipal water. As such, it is also important to introduce WSUD policy and legislation that specifically outlines the role that households can, and in some cases need to, play in the country's efforts to transition toward WSCs, or rather WSSs.

Community (and household) participation and cooperation are thus at the forefront of creating WSCs, which the implementation of WSUD aims to help realise. As such, simply publishing guidelines and policies will not ensure the successful uptake of WSUD measures (Beza et al., 2018; Toxopeus (a.), 2019). Equally important is the community's ability to live and work with the measures called for in a WSC. Therefore, the public's or community's "buy-in" to these measures is crucial for supporting WCSs. This is what this study partially aims to explore. Moreover, highlighting the role of households in implementing WSUD could provide valuable information, such as the types of WSUD measures that are feasible and convenient to take up at the household level. This will also impose the responsibility to conserve and protect water resources on households – i.e. in addition to municipalities and other water authorities – which often constitute the primary and active users of municipal water resources. As such, the study's research aim and objectives are outlined in the subsequent section.

1.5 Research Context, Aim and Objectives

1.5.1 Context of the Study

This study stems from a broader collaborative survey research project between the Council for Scientific and Industrial Research's (CSIR's) *Smart Places* cluster and the University of Pretoria's (UP's) departments of Psychology and Town and Regional Planning. Titled, *towards effective instruments for demand-side management in South Africa: A focus on urban household water use*, the survey was designed to collect various forms of data relating to water use in urban households. The data ranged from information on reported water use, water use activities and water conservation, to data on environmental attitudes, demographics, and the utilisation of and preference for various water-saving interventions such as municipal water DSM and WSUD. Surveys were conducted across six (6) metropolitan municipalities in South Africa. Namely, the Cities of Cape Town, Johannesburg, Tshwane, as well as Ekurhuleni, eThekwini and Mangaung. The CSIR and UP team conducted surveys in three of the six metros identified as part of the study, namely City of Tshwane, City of Johannesburg, and Ekurhuleni. The surveys were conducted between August 2018 and July 2019 (Jacobs-Mata et al., 2018).In total, over 1200 questionnaires were conducted across the six metropolitan areas. However, given the focus on household WSUD, as well as additional delimitations (as discussed in Chapter 3), results are based on a subsample of 250 households (N=250).

At the inception of the project, the relevant parties entered into a collaboration agreement, which outlined the following provisions:

> "UP students [are] to support a CSIR-funded project and conduct data collection for the project; [the] CSIR [is] to allow students to do their research and dissertations on the CSIR Project; and [the] CSIR and UP staff [are] to co-publish on project-related findings" (Jacobs-Mata, 2018, p. 1).

The questionnaire (APPENDIX 1) that was used to collect data features only three WSUD source control measures that can be taken up at site-scale, or household level, i.e., rainwater harvesting (RWH), permeable paving (PP) and greywater reuse (GWR) systems. The latter measure, as indicated, refers to GWR ***systems***, as opposed to general GWR, which includes manual techniques, such as the collection and conveyance of greywater using buckets or containers. As discussed in Section 1.2.4.5., GWR systems refer to automated systems such as a greywater diversion device and a greywater treatment system, amongst others.

Furthermore, respondents for the project in question were sampled from various types of areas and settlements – including formal, informal and mixed areas – i.e. across several metropolitan municipalities in South Africa. As a result, instead of WSUD, the questionnaire refers to WSD; which is done to acknowledge the application of the subject measures to settlements in general, which – for this particular project – were not limited to areas in formalised urban settings. Questions 14 and 26 of the questionnaire (APPENDIX 1) illustrate.

As a result, for this particular study, WSUD measures applicable at the household level were abridged to include only RWH, PP, and GWR. In addition to the limitations of the questionnaire, the site-scale WSUD measures were narrowed to RWH, PP, and GWR due to these measures being the most feasible ones for South African households to uptake, i.e. given the local economic context and technical capacity.

Taking the above into consideration, this study's research aim and objectives are presented below.

1.5.2 Research Aim and Objectives

Research aim

Research aim: This study aims to explore and describe urban households' uptake of Water Sensitive Urban Design measures across the City of Cape Town and the City of Tshwane, in order to outline possible directions for further research and to formulate indicative policy and planning recommendations for Water Sensitive Urban Design in a South African context.

Research objectives

Objective 1: To determine households' past, present, and future uptake of selected Water Sensitive Urban Design measures, including rainwater harvesting, greywater reuse systems, and permeable paving.

Objective 2: To examine the association between the current uptake of WSUD measures and factors that may influence uptake, including 'contextual and physical', 'behavioural and situational' and 'socio-demographic' factors.

Objective 3: To determine households' preference for *'assistance to implement Water Sensitive Design measures'* relative to other conventional demand-side management instruments.

The subsequent subsection outlines the description of the study's case areas, which include the City of Cape Town and the City of Tshwane.

1.5.3 Outline of the Study Areas

The City of Cape Town, identified here as a water-scarce study area, is a metropolitan municipality situated in the Western Cape province of South Africa. This metropolitan area has a land area of approximately 2460 km^2 and is home to about 3 740 026 people, resulting in a relatively high population density, with an average of 1 520.3 people per km^2. Situated along the western coast of southern Africa, the City of Cape Town has an average annual rainfall of 520mm, with a *coastal winter rainfall* climatic zone (Jacobs-Mata, 2018; Statistics South Africa, 2020; World Weather & Climate Information, 2010-2020).

Regarding the City of Tshwane, which is identified here as a relatively *less* water-scarce study area, the metropolitan municipality is situated in South Africa's Gauteng province. Furthermore, the City of Tshwane is home to around 2 921 488 people, with a land area of approximately 6345 km^2 and a relatively low population density of about 460.4 people per km^2. The Tshwane metropolitan area has an average annual rainfall of 718mm, with an *inland highlands summer* climatic zone (City of Tshwane, 2015; Jacobs-Mata et al., 2018; Statistics South Africa, 2020; World Weather & Climate Information, 2010-2020). Table 3 outlines the various physical characteristics of both the Cities of Cape Town and Tshwane.

Table 3: Comparison of physical characteristics of the Cities Cape Town and Tshwane

Characteristics	City of Cape Town	City of Tshwane
Province	Western Cape	Gauteng
Land Area (km^2)	2460	6345
Population (2011)	3 740 026	2 921 488
Average Population Density (Per km^2)	1 520.3	460.4
Climatic Zone	Coastal winter rainfall	Inlands highlands summer
2019/2020 Average Annual Rainfall (mm)	520	718

As highlighted in Section 1.1.3., the City of Cape Town has gone through a period of drought and severe water shortages in recent years. This was demonstrated by the City's progression towards a then imminent day-zero. As also noted in Section 1.1.3, *day-zero* represents a day in which the City of Cape Town's reticulation system was supposed to be turned off. However, in 2018, the City narrowly managed to avert a day-zero. (Institute for Security Studies, 2018; Sinclaire-Smith & Winter, 2018; Jacobs-Mata et al., 2018; Palafox Jr, 2019).

According to a small survey prepared by the World Wide Fund for Nature (WWF) and conducted among some Cape Town office staff members – it was discovered that Cape Town residents were still saving water months after a day-zero was averted and water use restrictions were relaxed. Furthermore, it was also discovered that most people were doing it out of fear of having another day-zero scenario happening again (Gosling, 2019).

Conversely, residents in the City of Tshwane have never experienced a day-zero scenario or something close to that. In fact, the highest level of water restrictions ever imposed on Tshwane residents is that of level 2; while a level 6b (bearing in mind that the larger the unit, the more stringent the water use restrictions are) constitutes the highest level of water use restrictions ever imposed on residents of the City of Cape Town; which was in 2018 (City of Tshwane, 2015; Jacobs-Mata et al., 2018; Sinclair-Smith & Winter, 2018). Therefore, given the two very different scenarios, all results for this study are compared between the Cities of Cape Town and Tshwane across each of the research objectives.

1.5.4 Rationale for the Study

This subsection outlines the reasoning behind the proposed research aim and objectives and the theoretical and practical contributions of each.

As deduced from the preceding section, the introduction and uptake of WSUD measures at the household level need to be approved, regulated and to some extent facilitated by the respective local authorities (i.e. municipalities). However, the adoption and implementation thereof require the acceptance and willingness of homeowners. The primary reason for this is that households that take up such measures become responsible for the performance and maintenance of the water infrastructure associated with the measures in question and thus assume the control and burdens over them (Domenech & Sauri, 2011; Gilbertson et al., 2011; Mankad & Tapsuwan, 2011; Barthwal et al., 2014; Feitelson et al., 2016; Valles-Casas et al., 2016). Therefore, and as contended by various scholars in the following statements, examining the dynamics surrounding the uptake of these measures at the household level is not only insightful and beneficial to policy developers but also necessary for the promotion, appropriate implementation and function, as well as consolidation of WSUD measures at household level (Brown & Davis, 2007; Ward et al., 2013):

> “. . . the current lack of insight into local community receptivity for domestic water reuse continues to contribute to the lack of local policy development to support the implementation of water reuse technologies across Sydney. There [is a] need to improve our understanding of how communities value and interact with domestic water uses . . . this knowledge should be developed from the perspective of explicitly understanding the communities’ capacity for response or ‘receptivity’ rather than primarily focusing on the evaluation of different policy for enabling change [i.e. to meet policy requirements or realise objectives]” (Brown & Davis, 2007, pp. 283 - 284).

> “Understanding the receptivity, including concerns and drivers of water users such as householders, is vital in facilitating the promotion, appropriate installation, end-use and maintenance of RWH systems” (Ward et al., 2013, p. 112).

> “Up to 50% of runoff from urban surfaces comes from private property, [therefore] fostering stormwater retention requires effective householder engagement” (Brown et al., 2016, p. 79).

> “Structural changes to buildings to accommodate SWM [stormwater management] systems (such as RWH or greywater reuse storage tanks) will have implications for water user behaviour, as well as the water using practices themselves. For example, depending on the level of automation integrated within a system, a householder (or building user) may have to consciously switch between different water sources or ensure water systems are functioning correctly. This not only necessitates behavioural adaptation to the technical aspects of the system itself, but also in relation to the use of different water qualities for different water practices . . . It is therefore crucial that the receptivity of this stakeholder group is assessed

> in order to build capacity at the household level, if RWH is to be more widely and more successfully implemented. . . Receptivity . . . of householders therefore provides a starting point for a range of other stakeholders to undertake informed actions towards supporting RWH implementation at the household scale (where appropriate) and beyond" (Ward et al., 2013, pp. 112-113)

Explorations into the uptake of WSUD measures at the household level provide several benefits; these include insights to inform policy; water infrastructure and support mechanism design and development, which are often required to promote and facilitate the adoption of these measures at the household level; as well as insights to inform the processes of promoting, appropriately installing and maintaining the measures at the same level (Brown & Davis, 2007; Ward et al., 2013). In essence, examining the uptake of various WSUD measures at the household level can inform the provision of effective support to homeowners, or households, who want or are required to take up the measures in question (Pinto & Maheshwari, 2010; Ward et al., 2013).

Furthermore, in their empirical study on GWR in Australia, Pinto & Maheshwari (2010) maintain the following:

> "However, to provide effective support to homeowners who want to reuse greywater, we need to understand people's views on water issues, their motivation for the reuse, impacts of reuse on soil, plant and human health in the term and factors that affect the adoption of widespread reuse practices" (Pinto & Maheshwari, 2010, p. 142).

The latter insight, i.e. '. . . *factors influencing the adoption of widespread reuse practices'*, forms part of one of the objectives of this study, i.e. Objective 2. However, in addition to exploring the factors influencing the adoption [or uptake] of greywater reuse (GWR) by urban households, factors influencing the adoption of RWH and PP by similar households are explored. As such, and as identified earlier, this study aims to explore urban households' uptake of selected WSUD measures, which include RWH, PP, and GWR (systems), i.e. by exploring the temporal uptake of the measures, i.e. over time; examining the factors influencing the uptake of WSUD measures at the domestic or household level; and by determining the household preference for *'assistance to implement WSD measures'* as a DSM instrument.

Moreover, determining households' past, current, and future uptake of selected WSUD measures provides insight into WSUD uptake level across several scenarios, i.e. across two metropolitan areas and several time frames. This insight could help determine if it is worthwhile for municipalities to invest in WSUD measures and technologies at the household level. Similarly, examining the association between the current uptake of selected WSUD measures and factors that may influence uptake also provides insight that municipalities can use to make informed decisions and develop targeted interventions. For instance, factors that are revealed to influence the uptake of selected WSUD across certain areas can be targeted and exploited to promote the uptake of the measures in question at the household level. Furthermore, determining households' preference for *'assistance to implement WSD measures'* demonstrates the importance of, and preference for, WSUD measures as DSM instruments, i.e. relative to other more traditional DSM instruments.

1.6 Dissertation Structure

This dissertation's *introduction* chapter – which sought to establish the context, scope and relevance of WSUD as a tool used to manage, and in some cases curb, the demand for water; define key concepts and identify the research aim and objectives – is followed by the *literature review* – which summarises the existing body of knowledge on WSUD at the household level. This is followed by the *methodology* chapter – which describes how the study in question was conducted while outlining its limitations – and the *findings and discussion* chapter – which is a presentation of the study's results. The *findings and discussion* chapter also serves to interpret key research findings and to contextualise the findings in the relevant existing body of knowledge, and is succeeded by the *recommendations for policy, planning practice and directions for further research* chapter, which is then followed by the *conclusion* chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

As informed by this study's research objectives, the purpose of this chapter is to discuss the key areas of scholarly research, or themes, emerging from published literature on the household uptake of selected WSUD measures, which include rainwater harvesting (RWH), permeable paving (PP) and greywater reuse (GWR); as well as the themes covered in the existing literature on water demand-side management (DSM) instruments that are applicable at the household level. As such, and as also informed by the research objectives of this particular study, the objectives of the literature review were: (1) to identify the key themes emerging from the literature on the household uptake of RWH, PP, and GWR; this was done to identify key areas of scholarly research in the existing body of knowledge and to identify gaps for this study to address. Moreover, with regards to examining the association between the current uptake of selected WSUD measures and factors that may influence uptake (i.e. the second research objective), (2) empirical literature on the factors that have been found to influence the household uptake of selected WSUD measures, i.e. RWH, GWR and PP, was also reviewed. This was done to identify factors to empirically examine in an effort to determine each factor's significance and the extent of influence, on the urban household uptake of selected WSUD measures. Finally, to address the third research objective, (3) literature on household water DSM instruments, as well as household perceptions of DSM instruments, was reviewed.

Furthermore, literature published between 1988 and 2020 was reviewed; this included both empirical and review studies on the topics in question, i.e. literature on the household uptake of selected WSUD measures, household DSM instruments, and literature on household preferences for water DSM instruments. Empirical studies made up the majority of the literature that was reviewed for this particular study (Cameron & Wright, 1988; Booth & Leavitt, 1999; Renwick & Green, 2000; Gilg & Barr, 2006; Brown & Davis, 2007; Finley, et al., 2009; Vernon & Tiwari, 2009; Noiseux & Hostetler, 2010; Parsons, et al., 2010; Pinto & Maheshwari, 2010; Domenech & Sauri, 2011; Gilbertson, et al., 2011; Makki, et al., 2011; Willis, et al., 2011; Dzidic & Green, 2012; Fielding, et al., 2012; Mayer, et al., 2012; Bjornlund, et al., 2013; Ward, et al., 2013; Attari, 2014; Barthwal, et al., 2014; Cote & Wolfe, 2014; Dascher, et al., 2014; Mukheibir, et al., 2014; Onufrak, et al., 2014; Chowdhury, et al., 2015; Garcia, et al., 2015; Hayden, et al., 2015; Zou, et al., 2015; Brown, et al., 2016; Coelho, et al., 2016; Brick, et al., 2017;Valles-Casas, et al., 2016; Charalambous, et al., 2018; Du, et al., 2018; Mason, et al., 2018; Schirmer & Dyer, 2018; Amodeo & Francis, 2019; Doria, et al., 2009; O'Donnell, et al., 2020); and these were followed by review studies (Terpstra, 1999; Inman & Jeffrey, 2006; Olmstead & Starvins, 2009; Maimon, et al., 2010; Mankad & Tapsuwan, 2011; Eilam & Trop, 2012; Fewkes, 2012; Wegelin & Jacobs, 2012; Lerer, et al., 2015; Feitelson, et al., 2016; Ahammed, 2017; Campisano, et al., 2017; Nakova, et al., 2017; Zelenakova, et al., 2017; and Lu, et al., 2019).

Moreover, a majority of the studies that were reviewed for this chapter, were conducted in North America (Cameron & Wright, 1988; Booth & Leavitt, 1999; Renwick & Green, 2000; Finley, et al., 2009; Olmstead & Starvins, 2009; Noiseux & Hostetler, 2010; Mayer, et al., 2012; Bjornlund, et al., 2013; Attari, 2014; Cote & Wolfe, 2014; Dascher, et al., 2014; Onufrak, et al., 2014; Hayden, et al., 2015; Zou, et al., 2015; Amodeo & Francis, 2019; O'Donnell, et al., 2020) and Australia (Brown & Davis, 2007; Vernon & Tiwari, 2009; Pinto & Maheshwari, 2010; Gilbertson, et al., 2011; Makki, et al., 2011; Willis, et al., 2011; Dzidic & Green, 2012; Fielding, et al., 2012; Mukheibir, et al., 2014; Brown, et al., 2016; Schirmer & Dyer, 2018); with several others conducted in Europe (Gilg & Barr, 2006; Parsons, et al., 2010; Domenech & Sauri, 2011; Ward, et al., 2013; Doria, et al., 2009; Garcia, et al., 2015; Valles-Casas, et al., 2016; Nakova, et al., 2017; Charalambous, et al., 2018; Lu, et al., 2019) and Asia (Barthwal, et al., 2014; Chowdhury, et al., 2015; Du, et al., 2018; Mason, et al., 2018). However, of all the studies that were reviewed for this chapter, the least amount of them were conducted in South America (Coelho et al., 2016), while a small amount of them was conducted in Africa (Wegelin & Jacobs, 2012; Baiyegunhi, 2015; Owusu & Teye, 2015; Brick, et al., 2017; Fisher-Jeffes et al., 2017; Nel et al., 2017; Rohr et al., 2017); with the former and latter three studies based in South Africa.

The limited amount of South African case studies on the household uptake of WSUD measures, as well as literature on household municipal water DSM instruments, possibly reflects a geographical and gap in the literature, particularly with regards to the lack of a diverse, comprehensive, and contextual body of knowledge on the household uptake of selected WSUD measures, as well as household-related municipal water DSM instruments – a gap which this particular study attempted to address by examining the uptake of selected WSUD measures, and the perceived effectiveness of various DSM instruments by urban households in South Africa.

2.2 Household Uptake of Selected WSUD Measures

The first objective of the literature review is to discuss literature on the household uptake of selected WSUD measures, i.e. RWH, PP, and GWR. The key themes or areas of scholarly research that emerged during the process of reviewing the literature are outlined below.

2.2.1 Household Uptake of Rainwater Harvesting

With regards to the literature on the household uptake of RWH, the definition of RWH, its benefits, as well as its viability and capacity as an alternative or supplementary household water source, i.e. in addition to the various factors influencing the latter, feature prominently in the existing body of knowledge on the topic. Below are some of the definitions provided for RWH in the literature:

> "The term RWH implies the intentional diversion of rainwater from roofs to a storage tank. The definition does not include indirect application of rainwater, even if intentional, if it is not stored prior to application" (Nel et al., 2017, p. 555)

> "RWH – the collection and storage of runoff from the roof/s present on an individual property within urban areas, and subsequent use within the property…" (Fisher-Jeffes et al., 2017, p. 81)

> "The collection of rainfall from the roof of a building, usually referred to as RWH, and its subsequent use for non-potable applications, such as water closet (WC) flushing or garden watering, is a simple method of reducing the demand on the public water supply… The concept of RWH systems is simple, consisting of the process of collecting, storing and using rainwater as a primary or supplementary water source." (Fewkes, 2012, p. 175)

Therefore, domestic RWH refers to collecting rainwater from a household roof and the subsequent storage and usage of the collected water to supplement or replace potable water source(s) (Fewkes, 2012; Fisher-Jeffes et al., 2017; Nel et al., 2017).

With regards to the benefits of RWH – reduction in potable water demands, the deferment of investments in future potable water infrastructure, improved resilience of households to volatile climate trends and increasingly variable rainfall patterns, as well as effective stormwater management through flood mitigation – feature as prevalent benefits in the existing body of knowledge (Fewkes, 2012; Mukheibir et al., 2014; Fisher-Jeffes et al., 2017). However, in their study that sought to explore and examine the viability of RWH as a water resource for households in South African urban areas, Fisher-Jeffes et al. (2017) argue that RWH is an unreliable means of attenuating excessive rainfall or flood events:

> "Researchers such as Petrucci et al. (2012), however, show that rainwater tanks 'affect the catchment hydrology for usual rain events, (but) are too small and too few to prevent sewer overflows in the case of heavy rain' " (Fisher-Jeffes et al., 2017, p. 82)

Similarly, in addition to greywater and groundwater, RWH, or rainwater, commonly features as an alternative or supplement to centralised potable water supplies for households (Domenech & Sauri, 2011; Mukheibir et al., 2014; Garcia et al., 2015; Fisher-Jeffes et al., 2017; Nel et al., 2017). Moreover, the viability of RWH, as a means to produce a supplementary water source for households, as well as the reliability of rainwater as a substitute for potable water, constitutes a prominent research area for published studies on the household uptake of RWH (Fewkes, 2012; Cote & Wolfe, 2014; Mukheibir et al., 2014; Ahammed, 2017; Fisher-Jeffes et al., 2017; Nel et al., 2017).

The amount of rainwater generated by the RWH systems, the financial viability of RWH infrastructure, as well as the willingness of households to adopt or take up RWH, which is also referred to as *user acceptance*, are highlighted as some of the primary determinants of the viability of RWH infrastructure (Fewkes, 2012; Cote & Wolfe, 2014; Mukheibir et al., 2014; Ahammed, 2017; Fisher-Jeffes et al., 2017; Nel et al., 2017). Regarding the amount of rainwater generated by RWH systems and technologies, the functionality and regular maintenance of the pertinent system(s) emerged as major factors influencing the rainwater yields. For instance, in their (2014) paper discussing the role and extent of the functionality of rainwater tanks as reliable substitutions for potable residential water supply infrastructure, Mukheibir et al. (2014) maintain the following:

> "The substitution of mains [potable] supplied water by rainwater can vary significantly, with the major factors influencing yields being:
>
> - The roof size to capture the rainwater usage regime (i.e. having some level of internal water use)
> - Tank size, as well as
> - Tank performance, with respect to reduced substitution as a result of functionality failure…
>
> …The substitution of mains water through a rainwater tank system is directly linked to how well the rainwater capture and end-use connection system is operating. This is thus referred to…as the functionality of a rainwater tank system." (Mukheibir, et al., 2014, p. 377)

Moreover, in their study examining the impact of alternative water sources on municipal water infrastructure, Nel et al. (2017) note that "in addition to the acceptance of rainwater as a domestic source, the training of consumers to maintain and use the tank system optimally was essential to ensure that social development projects involving rainwater use would be sustainable" (Nel et al., 2017, p. 555). Also, according to Nel et al. (2017), additional factors such as climate conditions, rainfall patterns, as well as the water use activities (i.e. end-uses) of rainwater significantly influence the viability of domestic RWH, i.e. in terms of producing enough rainwater to supplement potable supplies (Nel et al., 2017).

With regards to the financial viability of RWH systems, numerous scholars argue the need to make the cost of RWH technologies competitive with conventional potable water supplies (Ahammed, 2017; Fisher-Jeffes et al., 2017). For instance, Fisher-Jeffes et al. (2017) argue that the relatively cheap cost of municipal water, i.e. in South Africa, does not make RWH financially viable for most households. Moreover, they maintain the following:

> "A significant challenge to the wider adoption of RWH in RSA (and elsewhere) is that the cost of RWH typically has an inverse relationship with water demand. As a result, the CoCT's [i.e. City of Cape Town's] current block tariff structure, which has no charge for the first 6k*l* per hh

[i.e. per household] per month and then increasing unit rates as the monthly demand increases, acts as a disincentive to small users of water to harvest rainwater, even if, at a capita level, they are using large volumes of water." (Fisher-Jeffes et al., 2017, pp. 84-85)

However, they suggest the following in response:

"As a consequence, should RWH be considered in the CoCT [City of Cape Town] and the rest of RSA, it would be important to encourage the installation of systems in which water is used as diversely as possible...This would reduce the scale of the required adjustment to the tariffs in order to incentivise users to adopt RWH while concurrently ensuring a greater reduction in demand for municipal water…" (Fisher-Jeffes, et al., 2017, p. 86)

"If the local authority wishes to incentivise the widespread adoption of RWH by making it more economically attractive, it would need to either offer a subsidy to households who install RWH systems (e.g. to cover the capital costs) or to increase water tariffs by between 2 and 4 times over 2013 rates." (Fisher-Jeffes, et al., 2017, p. 88)

With regards to the determinants of user acceptance, or rather households' willingness to take up RWH – a household or water user's awareness of RWH, including its functions and benefits, and water user perceptions, personal preferences and social norms, emerged prevalently as some of the factors influencing households' willingness to adopt RWH (Fewkes, 2012; Mukheibir et al., 2014; Ahammed, 2017; Nel et al., 2017; Reese et al., 2019). It is argued that a water user's acceptance of RWH as an alternative domestic water source contributes to its viability and simplifies the implementation and proliferation of the measure. For instance, using maintenance as an example, Mukheibir et al. (2014) argue the following:

> "The literature… also suggests that voluntary rainwater tank owners are more motivated and hence more likely to maintain their system than those who have been forced to install one because of regulations." (Mukheibir, et al., 2014, p. 382)

Furthermore, risk perceptions in the form of health concerns emerged as one of the primary factors influencing user acceptance. For instance, in his (2017) paper discussing published research on WSUD, Ahammed (2017) notes that types of micro-organisms and pathogens commonly found in harvested rainwater often act as key barriers to the adoption of RWH by water users or households; while Fewkes (2012) identifies the absence of water quality standards and the consequent public health concerns as one of the main barriers to the wider uptake of RWH systems in the UK (Fewkes, 2012; Ahammed, 2017). Moreover, in terms of personal preferences, Fewkes (2012) notes that the acceptance of a RWH system by the user is usually related to the aesthetic quality of the harvested water; which is often expressed in terms of colour, odour and turbidity (Fewkes, 2012, pp. 183-184).

Social norms, which often perpetuate modern cultural preferences for lawns and non-native plant species, which usually consume significant amounts of water, have been found to influence households' acceptance of and willingness to take up RWH. For example, Nel et al. (2017) assert that "outdoor residential environments have been found to be extremely important to homeowners… [and that these] also [affect] residents' sense of social status or acceptance in [their respective] neighbourhood(s)" (Nel et al., 2017, p. 553).

Social norms are defined by Reese et al. (2019) as:

> " …rules of behaviour. They inform group members how to construe a given situation, how to feel about it, and how to behave in it. They exert social influence on group members by prescribing which reactions are appropriate, and which are not...Social norms hence direct [an] individual's cognitions, emotions, and behaviours. They also serve as evaluative standards, against which individuals' reactions are judged." (Reese, et al., 2019, p. 80)

As such, numerous scholars argue that the preference for water-consuming lawns, as perpetuated by social norms, coupled with the introduction of water use restrictions that often prohibit the use of potable municipal water sources for irrigation and other outdoor water use activities – encourage households or residents to take up alternative sources of water, even if it is only for irrigation purposes (Fisher-Jeffes et al., 2017; Nel et al., 2017). For instance, according to Nel et al. (2017):

> "Reliable potable municipal supply to urban consumers via the water distribution system is typically linked to relatively low uptake of [supplementary] household water sources. However, stringent water restrictions in some large South African cities that prohibit outdoor use, and reports of intermittent water supply, have led to increased uptake of [alternative] household [water] sources in South Africa… Consumers with suburban gardens are thus turning to supplementary water sources to meet garden irrigation demands, including rainwater, groundwater and greywater" (Nel et al., 2017, p. 553).

As such, the introduction and enforcement of particular household water use restrictions could be used to indirectly encourage the uptake and use of selected WSUD measures such as RWH and GWR.

2.2.2 Household Uptake of Permeable Paving

The definition, benefits and effectiveness of PP, as well as the viability of its adoption at a household level, constitute the key areas of scholarly focus for literature on the household uptake of PP (Cote & Wolfe, 2014; Ahammed, 2017; Nakova et al., 2017; O'Donnell et al., 2020). For instance, Cote and Wolfe (2014) define PP as a type of Low Impact Development (LID) practice that allows water, i.e. precipitation or stormwater, to infiltrate the soil (Cote & Wolfe, 2014). With regards to the benefits of PP, the management and reduction of stormwater quantities (as generated by the intensification of development in urban areas) through flood control and mitigation; the minimisation of waste as well as stormwater capital and operation costs; and the improvement of stormwater quality – featured commonly in the existing body of knowledge (Cote & Wolfe, 2014; Sharma et al., 2016; Ahammed, 2017).

In terms of PP's effectiveness, both the infiltration capacity and pollutant removal performance feature as common approaches used to measure the effectiveness of PP (Cote

& Wolfe, 2014; Ahammed, 2017). Infiltration capacity is concerned with the ability of PP, or rather permeable pavements and surfaces, to infiltrate the soil and recharge the respective groundwater tables, while the pollutant removal performance focuses on the ability of PP to protect and improve the quality of the infiltrated water. For instance, Ahammed (2017) notes that in addition to studies that analyse the pollutant load removal efficiency, the literature on PP also focuses on improving the permeability of various types of permeable surfaces but that the mechanical performance (i.e. infiltration capacity) of permeable pavements under heavy loads, is still questioned (Ahammed, 2017). Similarly, the maintenance and lifespan of PP emerged as one of the primary factors influencing the effectiveness of PP (Ahammed, 2017).

Regarding the viability of PP, a key determinant thereof, as featured in the literature, is user acceptance (Cote & Wolfe, 2014; O'Donnell et al., 2020). For instance, Cote and Wolfe (2014) argue that "…for permeable surfaces to be adopted and widely installed, homeowners must easily recognise this practice as being beneficial." (Cote & Wolfe, 2014, p. 7).

Moreover, in addition to various other factors such as an adopter's, or a households' physical capacity, access to capital costs, knowledge and awareness – attitudes and perceptions, particularly the perceived risks associated with the measure, were also identified as potential barriers to a water user's acceptance of or willingness to adopt PP (Cote & Wolfe, 2014; O'Donnell et al., 2020). For instance, risk perceptions, such as changes in property value resulting from retrofitting household surfaces with PP, also emerge as an influential factor, i.e. in terms of user acceptance (Cote & Wolfe, 2014). However, contrary to the adoption of RWH and GWR, i.e. in terms of modern cultural preferences for lawns, and as perpetuated by social norms – it is argued that PP, in and of itself, might deter homeowners from taking it up, as a result of the perceived aesthetical attractiveness, or in this case unattractiveness of some aspects of PP such as weed growth (Cote & Wolfe, 2014; Hayden et al., 2015; Ahammed, 2017; O'Donnell et al., 2020). Hayden et al. (2015) further elaborate on this:

> "In contrast to agricultural contexts, the look and feel of the landscape is an important consideration for homeowners. Several homeowners have found that aesthetics are often the primary focus of landscaping decisions, while environmental and other concerns are subsidiary…Therefore, it is crucial to recognise the role that aesthetic preferences play in homeowner willingness to adopt BMPS [Best Management Practices] and how

> important aesthetics are relative to other factors such as water conservation…The neighbourhood context in which a landscape is situated also plays a role in shaping preference. As a result, residential landscaping is spatially autocorrelated, meaning that residents take the landscaping of their neighbours into consideration when making their own landscaping decisions, and, therefore, yards closer to each other will look more similar than yards farther apart…Although there is a general trend to conform to the traditional suburban landscape stereotype of a lush green lawn, residents place a higher priority on maintaining the "look" or style of the landscaping in their immediate surrounding…" (Hayden et al., 2015, p. 2)

Therefore, to ensure the widespread adoption of similar measures, current trends and community preferences need to be reformed so that the adoption or uptake of various WSUD measures, including PP, becomes normalised and enabled by social norms.

2.2.3 Household Uptake of Greywater Reuse

With regards to the literature on the household uptake of GWR, the definition for greywater, the benefits of GWR, as well as its viability as a supplementary water source for households feature as key themes in the relevant body of knowledge (Pinto & Maheshwari, 2010; Maimon et al., 2010; Fewkes, 2012; Hayden et al., 2015; Nel et al., 2017). Below are some of the definitions for greywater as provided for in the existing body of knowledge:

> "Greywater [refers to] all domestic sewage, with the exception of wastewater generated by toilets and bidets" (Maimon et al., 2010, p. 3213)

> Greywater is a term often used to describe sullage. Sullage is defined…as 'waste from household sinks, showers and baths, but not toilets.' " (Nel et al., 2017, p. 555)

> "Greywater is defined as all untreated domestic wastewater other than toilet water and wastewater from the kitchen (kitchen sinks and

> dishwashing machines). Other water that may be contaminated with harmful pathogens, such as water used for baby and nappy washing, is also excluded from greywater to be potentially used as a water resource. Greywater therefore includes wastewater from baths, basins, and laundry. Greywater is not only produced on private residential stands, but also at communal washing places, businesses, and taxi ranks." (Council for the Scientific and Industrial Research; Department of Human Settlements, 2019, p. J.45)

Therefore, GWR refers to the fit-for-purpose use of [generated] greywater. Moreover, with regards to the benefits of GWR, the reduction of potable water supply costs for residents, the alleviation of pressure on depleting potable water resources and the reduced inflow of wastewater to treatment facilities were identified during the process of reviewing the published literature on the household uptake of GWR (Maimon et al., 2010; Pinto & Maheshwari, 2010; Nel et al., 2017). In addition, Maimon et al. (2010) argue that "the use of greywater for toilet flushing and garden irrigation has the potential to reduce domestic water consumption by up to an estimated 50%" (Maimon et al., 2010, p. 3213).

Conversely, Nel et al. (2017) highlight the paradox associated with the uptake, or adoption, of GWR:

> "Also, the available yield from greywater is limited to how much water is used for bath, shower and washing machine indoors. Further research is needed to link greywater generation to water conservation. Conservation of water at the bath, shower and washing machine is likely to reduce greywater yield[s] from the same home, because the end-use event volume directly generates greywater for re-supply." (Nel, et al., 2017, p. 560)

In terms of the viability of GWR as a supplementary household water source – user acceptance, as influenced by awareness, perceptions as well as the aesthetical preferences of water users, emerged as a key determinant (Maimon et al., 2010; Fewkes, 2012; Hayden et al., 2015; Nel et al., 2017). For example, Fewkes (2012) argues that a water user's impression and attitude towards a water recycling or reuse scheme can undermine it, i.e. irrespective of the scientific evidence (Fewkes, 2012). On the other hand, risks perceptions emerged as significant barriers to a water user's or household's willingness to adopt GWR (Maimon et al., 2010; Nel et al., 2017).

To illustrate, Nel et al. (2017) assert the following:

> "For many of the intended end-uses water can be reused directly without treatment, but issues regarding environmental pollution and community health are becoming increasingly important, especially for greywater reuse" (Nel, et al., 2017, p. 553).

Moreover, Maimon et al. (2010) note that GWR can compromise both human and environmental health; the health risks associated with greywater use for activities such as irrigation can damage the soil structure and consequently reduce plant productivity (Maimon et al., 2010). Thus further highlighting the significance of risk perception regarding households' or water users' acceptance of GWR.

2.2.4 Summary: Household Uptake of selected Water Sensitive Urban Design Measures

As outlined above, existing literature on the household uptake of selected WSUD measures, including RWH, PP and GWR – commonly defines the measures and identifies the benefits associated with each of them. Furthermore, the viability of the measures in question, particularly with regards to the viability of RWH and GWR as tools for producing alternative sources of water for households, also features commonly as a topic in the relevant body of knowledge; with factors influencing the viability of the measures in question featuring just as much. In particular, a household's or water user's acceptance of selected WSUD measures emerged as a prevalent factor influencing the viability of the household uptake of each of the measures. Similarly, the economic viability of taking up each of the selected measures at the household level is also addressed by a significant number of studies on the household uptake of selected WSUD measures.

However, it is important to note that selected WSUD measures such as RWH and GWR are commonly identified and discussed as alternative and supplementary household water sources (Maimon et al., 2010; Fewkes, 2012; Mukheibir et al., 2014; Fisher-Jeffes et al., 2017; Nel et al., 2017), while RWH and PP are predominantly identified as either urban design BMPS, green infrastructure (GI), flood protection measures, or natural water retention measures (NWRM) (Cote & Wolfe, 2014; Hayden et al., 2015; Charalambous et al., 2018; Amodeo & Francis, 2019; O'Donnell et al., 2020). In fact, only Ahammed (2017) and Schirmer and Dyer (2018) constitute some of the very few scholars that have attempted to link the notion of WSUD to the measures in question. As such, this particular study is designed to form part of the few existing studies that refer to RWH, PP and GWR as WSUD measures.

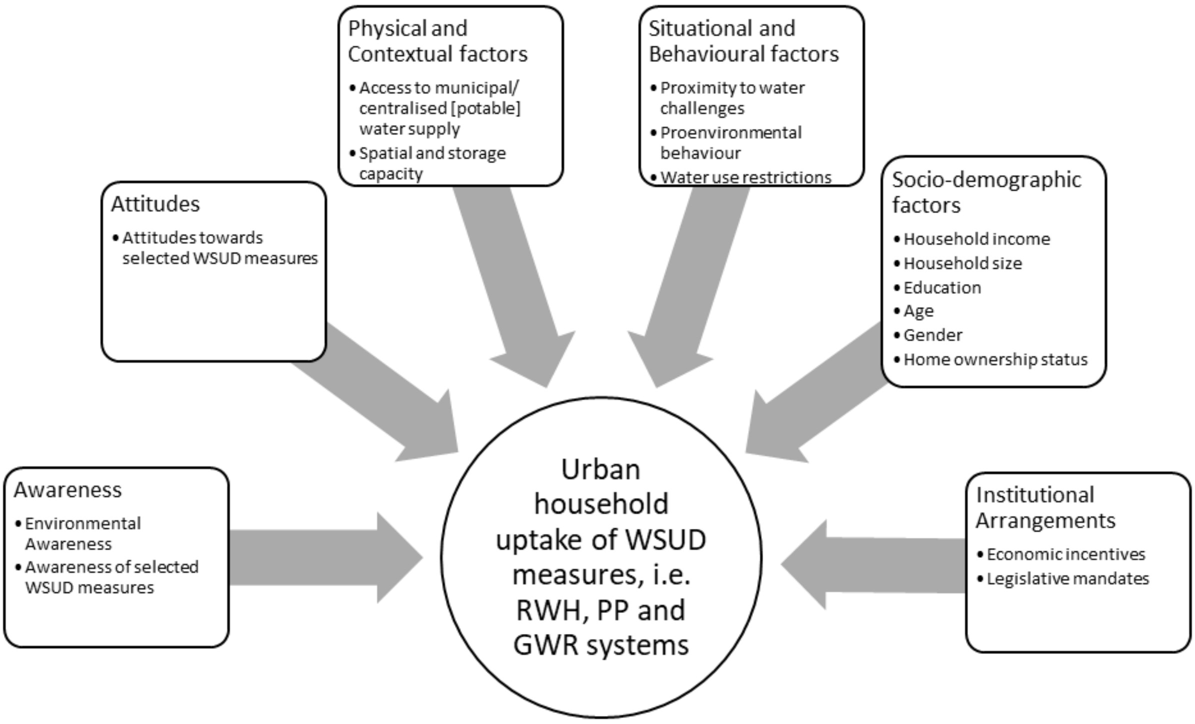
Furthermore, there is a considerable lack of literature on the temporal aspect of the household uptake of WSUD measures, particularly over varying periods of time, i.e. past, present and future. However, such studies are usually context-based as results are typically dependent on the relevant contexts of application, which include attributes such as case area(s) and characteristics of the relevant target population(s). Therefore, in addition to acknowledging RWH, PP and GWR as WSUD measures – the inclusion of this 'temporal' aspect of the research (as addressed in the study's first research objective) is reflective of the study's niche.

2.3 Factors Influencing the Household Uptake of Selected Water Sensitive Urban Design Measures

The second objective of the literature review, which is to discuss the factors that have been found to influence the uptake of the selected WSUD measures by urban households, is addressed in this section. It is important to note that some of the factors outlined in this section were briefly highlighted earlier as part of the factors influencing the willingness of water users or households to adopt or take up the measures in question, i.e. RWH, PP and GWR; also known as user acceptance. However, for the purpose of this section, the review was not limited to factors influencing a water user's acceptance of selected WSUD measures but rather includes a comprehensive exploration of all factors that have been found to have an influence on the household uptake of selected WSUD measures, including the ones that might not be related to user acceptance.

Therefore, and as derived from the existing body of knowledge, numerous factors have been found to influence the uptake of selected WSUD measures, i.e. RWH, PP, and GWR, by urban households. These factors have been organised into 6 sets, which include **Awareness** factors, factors related to individual **Attitudes**, **Physical and Contextual** factors, **Socio-demographic** factors, **Situational and Behavioural** factors, and factors related to **Institutional Arrangements**. Each of the factors found to influence urban households' uptake of selected WSUD measures are identified and discussed below as part of their relevant sets, which are also presented in Figure 6(a) below.

Figure 6(a): Factors influencing household uptake of Water Sensitive Urban Design measures



As illustrated in Figure 6(a), a total of 16 factors were identified as factors that have been found to influence the uptake of the selected WSUD measures – i.e. RWH, PP, and GWR – by urban households. These factors have been organised into six sets, which include *awareness*, *attitudes*, *physical and contextual* factors, *situational and behavioural* factors, *socio-demographic* factors, and *institutional arrangements*. These sets, along with the factors identified as part of each, are outlined and discussed below.

2.3.1 Awareness

Awareness, which refers to the state of being conscious of something, or rather the ability to know and be cognisant of something, or in some cases, someone – was identified as one of the sets of factors that may influence the household uptake of RWH, PP and GWR. Under this particular set, two factors were identified during the process of reviewing the existing literature on the relevant topic. These include environmental awareness, as well as awareness of selected WUSD measures themselves (Noiseux & Hostetler, 2010; Fewkes, 2012; Barthwal et al., 2014; Cote & Wolfe, 2014; Hayden et al., 2015; Charalambous et al., 2018; Schirmer & Dyer, 2018).

2.3.1.1 Environmental Awareness

In their (2018) study on the association between environmental awareness and the local environmental management of water conservation zones, Du et al. (2018) provide the following definition for environmental awareness, which has also been adopted for this study:

> "Environmental awareness can be defined as the ability of an individual to understand the connection existing between: (a) human activities, (b) the current status of environmental quality, and (c) his/her willingness to take part in environment activities…" (Du et al., 2018, p. 3 of 24)

Therefore, for this particular study, *environmental awareness* refers to a person's knowledge or cognisance about the state of water resources, the environmental challenges facing the water resources, the importance and value of water, as well as the effect of the individual's actions, choices or behaviour on water resources (Noiseux & Hostetler, 2010; Barthwal et al., 2014; Du et al., 2018; Schirmer & Dyer, 2018). As argued by various scholars, this degree of awareness often serves as a predictor of an individual's, water user's, or household's pro-environmental behaviour, which includes the uptake of WSUD measures. For instance, according to Hayden et al. (2015), "… acceptance of water conservation practices is greater among those with higher awareness." (Hayden et al., 2015, p. 3). Moreover, Schirmer and Dyer (2018) observed that homeowners' use of *water quality-*

protective gardening methods was considerably linked to their awareness of challenges to the water quality in neighbouring lakes; they also maintain that the "awareness of environmental problems is often considered a prerequisite to taking action to address them." (Schirmer & Dyer, 2018, p. 7691).

Various scholars recommend the education of water users on environmental issues such as the state of water resources, as well as the impact of their actions on those resources (Noiseux & Hostetler, 2010; Cote & Wolfe, 2014; Charalambous et al., 2018; Schirmer & Dyer, 2018). For example, according to Charalambous et al. (2018), in addition to surveys and subsidies, the practical conveyance of information can build awareness and facilitate the engagement of people (Charalambous et al., 2018).

However, although Schirmer and Dyer (2018), as well as Noiseux and Hostetler (2010), respectively acknowledge the significance of environmental awareness as a factor as well as the significance of education in promoting awareness, they both argue for the importance of translating environmental awareness, or knowledge, into sustainable practices (Noiseux & Hostetler, 2010; Schirmer & Dyer, 2018). For instance, according to Schirmer and Dyer (2018), individuals often do not know how their actions can help address the environmental problem(s) they find themselves in. These scholars further suggest that for individuals to trigger behavioural change, the fostering of awareness of environmental problems needs to co-occur with actions intended to address the problems (Schirmer & Dyer, 2018). On the other hand, Noiseux and Hostetler (2010) recommend future studies on the topic to monitor residents' translation of environmental comprehension into everyday practices (Noiseux & Hostetler, 2010).

2.3.1.2 Awareness of Water Sensitive Urban Design Measures

Awareness of the selected WSUD measures, i.e. RWH, PP and GWR, as well as awareness of the potential of these measures to address water challenges and meet individual needs, i.e. in addition to various other associated benefits, emerged as one of the factors that have been found to influence the urban household uptake of the measures in question (Barthwal et al., 2014; Cote & Wolfe, 2014; Brown et al., 2016; Charalambous et al., 2018; O'Donnell et al., 2020). For instance, in their case study aimed at evaluating community acceptance of RWH systems in Dehradun, India, Barthwal et al. (2014) discovered that respondents' level of awareness and household income positively influenced their willingness to invest in RWH systems (Barthwal et al., 2014). Brown et al. (2016) also noted similar findings in their study on the Little Stringybark Creek (LSC) project, which made use of economic incentives and awareness building programs to facilitate and promote the use of rain barrels (i.e. RWH infrastructure) and rain gardens to stimulate change in how stormwater runoff from domestic properties is managed (Brown et al., 2016). Furthermore, Barthwal et al. (2014) also observed that the willingness to invest in RWH was highest among respondents who were aware of the fact that a substantial amount of rainwater can be stored through RWH as well as among those who deemed rainwater safe for consumption (Barthwal et al., 2014).

As a result, several scholars believe that warranting and enhancing access to information will likely improve the acceptability and subsequent adoption, or uptake, of the measures by water users and households (Barthwal et al., 2014; Cote & Wolfe, 2014; Brown et al., 2016; Charalambous et al., 2018). For example, in their (2014) study on the assessment of social and economic barriers to the utilisation of permeable surfaces in residential driveways, Cote and Wolfe (2014) discovered that residents' poor awareness of stormwater management and types of permeable surfaces acted as a barrier and that this was because problem recognition and subject knowledge often influences adoption (Cote & Wolfe, 2014). Furthermore, Fewkes (2012) notes that the "lack of knowledge and information relating to water recycling and reuse systems amongst the various stakeholders [acts] as one of the main barriers to their wider application and use" (Fewkes, 2012, p. 189).

Similar to the factor of *environmental awareness*, awareness building among water users and education efforts targeted at intended users – i.e. particularly regarding the purpose and benefits of measures in question – emerged as a prevalent recommendation. To illustrate, according to Cote and Wolfe (2014), both "promotional and educational efforts are also required in order to improve stormwater issue awareness and knowledge related to permeable surface benefits, costs, and characteristics." (Cote & Wolfe, 2014, p. 15). Charalambous et al. (2018) take it a step further by suggesting that the promotion of household level flood protection measures – which include RWH, PP and green roofs – through subsidies will increase the public's willingness to adopt them, or rather take them up (Charalambous et al., 2018).

2.3.2 Attitudes

Attitudes, which Eilam and Trop (2012) define as “a person’s overall evaluation[s] of persons (including oneself), objects and issues.” (Eilam & Trop, 2012, p. 2212), constitutes another factor set that has been found, i.e., in the existing body of knowledge, to influence the urban household uptake of selected WSUD measures. As such, a water user’s, or in this case household’s, attitude towards selected WSUD measures, i.e. RWH, PP and GWR, was identified as a factor that has been found to influence the uptake of the measures in question by urban households (Brown & Davis, 2007; Finley et al., 2009; Pinto & Maheshwari, 2010; Domenech & Sauri, 2011; Mankad & Tapsuwan, 2011; Dzidic & Green, 2012; Ward et al., 2013; Barthwal et al., 2014; Baiyegunhi, 2015; Chowdhury et al., 2015; Feitelson et al., 2016; Valles-Casas et al., 2016; Campisano et al., 2017; O'Donnell et al., 2020). Eilam and Trop (2012) describe the term *attitude* as:

> “An enduring combination of motivational, emotional, *perceptual* and cognitive processes with respect to some aspect of our environment [as well as a] learned predisposition to respond in a consistently favourable or unfavourable manner with respect to a given object” (Eilam & Trop, 2012, p. 2212, ***emphasis mine***)

…which, in this case, refers to the quality and quantity of [potable] water, as well as the consequent adoption or uptake of selected WSUD measures, i.e. RWH, PP and GWR.

Thus, as informed by the provided description, perceptions constitute a key aspect of attitude; one might even go as far as to deem attitudes as a by-product of one’s perceptions. To illustrate and using the environment as a subject, Du et al. (2018) provide the following definitions to distinguish between the two concepts:

> “Environmental perception refers to the knowledge of, or feelings about, the environment, and the act of understanding the environment through our senses. It is the understanding of the environment resulting from visual, auditory, and tactile experience, and also by information disclosure… (Du, et al., 2018, p. 3 of 24)

> "…environmental attitude refers to the emotional response of people to environmental problems, which may trigger positive action for the environment." (Du, et al., 2018, p. 3 of 24)

Thus, for the purpose of this study, the term attitude refers to an intended water user's evaluation of selected WSUD measures, as well as his/her consequent response to the measures in question. As a result, both positive and negative attitudes towards selected WSUD measures were identified as factors that may, and in some cases, have been found to influence the urban household uptake of RWH, PP and GWR. The key contentions concerning domestic water users' positive and negative attitudes towards selected WSUD measures, i.e. as found in the existing literature, are outlined below.

2.3.2.1 Attitudes towards Water Sensitive Urban Design measures

Positive Attitudes

As highlighted earlier, individual attitudes feature prominently in the existing body of knowledge as one of the factors influencing the household uptake of selected WSUD measures. This includes both positive and negative attitudes towards the measures in question. The positive or pro-environmental attitudes, which are partly derived from the perceived benefits associated with the adoption of the selected measures, have (in some cases) been found to enable households' uptake of the measures in question. Conversely, negative attitudes, which are usually associated with the perceived costs of taking up the selected measures, have been found to act as barriers to adopting such measures at the household level (Baiyegunhi, 2015; O'Donnell et al., 2020). For example, in his rural-based case study, Baiyegunhi (2015) observed that farmers who had positive attitudes toward rainwater harvesting technology (RWHT) were more likely to take it up (Baiyegunhi, 2015).

Positive attitudes towards selected WSUD measures stem from various influences, including anticipated savings in potable water for purposes of environmental conservation and sustainability; future savings on water bills (as primarily enabled by GWR and RWH) as well as perceived water security, particularly the perceived independence from water shortages and water use restrictions (Domenech & Sauri, 2011; Mankad & Tapsuwan, 2011; Valles-Casas et al., 2016; Campisano et al., 2017). For instance, results from a survey study by

Campisano et al. (2017) revealed potable water savings as the biggest motivator amongst respondents to install RWH systems; while Domenech and Sauri (2011) as well as Valles-Casas, et al. (2016) identified both environmental conservation and water savings as key motivators (Domenech & Sauri, 2011; Valles-Casas et al., 2016). Savings on household water usage bills as well as alleviation of the effects of water use restrictions on households are perceived as some of the benefits associated with the use of alternative and/or decentralised water systems, such as RWH, GWR and groundwater abstraction point (GAP) systems (Mankad & Tapsuwan, 2011; Nel et al., 2017).

Negative Attitudes

The negative attitudes towards the selected WSUD measures stem from various factors, ranging from perceived installation costs and maintenance commitments to perceived or anticipated disruptions around the home during system installations, image or aesthetic concerns, as well as perceived health risks (Brown & Davis, 2007; Finley et al., 2009; Pinto & Maheshwari, 2010; Mankad & Tapsuwan, 2011; Dzidic & Green, 2012; Ward et al., 2013; Barthwal et al., 2014; Mukheibir et al., 2014; Chowdhury et al., 2015; Feitelson et al., 2016; Campisano et al., 2017). For example, Brown and Davis (2007) as well as Pinto and Maheshwari (2010), identified retrofitting and plumbing costs, along with the perceived health risks associated with the quality and use of greywater, as major barriers to a household's uptake of GWR (Pinto & Maheshwari, 2010; Brown et al., 2016). Moreover, 52% of respondents from Ward et al.'s (2013) study perceived *regular maintenance commitment* as a discouraging factor to installing an RWH system, while 52% and 48% respectively identified *having to pay for* [system] *maintenance* and *having disruption to the home/life during installation* as additional discouraging factors (Ward et al., 2013).

Perceived health risks – which relate to concerns regarding the effect of varying levels of water quality associated with the selected measures, particularly RWH and GWR, on the health of the soil, plants and people – have been prevalently found to influence the uptake of the measures in question by urban households (Brown & Davis, 2007; Finley et al., 2009; Pinto & Maheshwari, 2010; Mankad & Tapsuwan, 2011; Dzidic & Green, 2012; Ward et al., 2013; Feitelson et al., 2016; Campisano et al., 2017). Notably, Mankad and Tapsuwan (2011) observed that people's *perceptions* of health risks associated with the use of recycled or greywater influenced their acceptance of greywater much more than the actual health risk (Mankad & Tapsuwan, 2011).

Furthermore, as part of their respective studies, several scholars noted that a majority of respondents preferred supplementing their potable water with rainwater, as opposed to greywater; and that community *receptivity*, which is defined by Ward, et al. (2013) as a person's, or household's, willingness and ability to consider implementing an RWH system (or any other similar system or measure), was highest for external uses such as watering the garden, irrigation, flushing toilets, washing cars, etc. and that receptivity to both RWH and GWR progressively decreased with increases in personal contact (Brown & Davis, 2007; Finley et al., 2009; Pinto & Maheshwari, 2010; Dzidic & Green, 2012; Ward et al., 2013; Barthwal et al., 2014; Feitelson et al., 2016). For instance, both Pinto and Maheshwari (2010), as well as Feitelson et al. (2016), note that the use of greywater often raises some health concerns relating to human health, as well as concerns about the impacts of greywater on soils and plant life and that these concerns are primarily attributed to the presence of pathogens in greywater (Pinto & Maheshwari, 2010; Feitelson et al., 2016).

Similarly, results from a study by Chowdhury et al. (2015) revealed that approximately 70% of respondents agreed to reuse greywater for gardening purposes while only 18% agreed to reuse greywater for toilet flushing (Chowdhury et al., 2015). With regards to RWH, 86% of respondents from a study by Barthwal et al. (2014) considered rainwater harvested from rooftops safe for non-potable consumption (Barthwal et al., 2014); while Ward et al. (2013) noted that 38%, 57% and 62% of respondents who respectively identified *personal washing*, *other potentially ingestible uses* and *drinking* as domestic practices, were not willing to execute the relevant practices using rainwater (Ward et al., 2013).

Conversely, as part of their Barcelona-based case study on domestic RWH in both single and multi-family dwellings, Domenech and Sauri (2011) note that for Sant Cugat del Valles (Barcelona) residents, community perceptions and health risks did not emerge as particular areas of concern; but identified high capital costs as the key barriers to their willingness to adopt RWH (Domenech & Sauri, 2011). A possible explanation for this could be linked to low levels of awareness and limited access to information about the health risks associated with the domestic use of rainwater. For example, Pinto and Maheshwari's (2010) study on the use of greywater for irrigation in suburban Australia revealed a high level of concern amongst respondents with regards to using greywater on gardens, plants and lawns, as well as the effects of the contents of greywater on the soil and plants. Several respondents further expressed their appeal for more information on greywater, accompanied by appropriate end-uses (Pinto & Maheshwari, 2010). As such, respondents from the Sant Cugat del Valles case study may not have been exposed to the same access to and level of information as to their Australian counterparts; therefore, at the time of the study, Domenech and Sauri's (2011) respondents may have been eluded by the possibility that RWH technology and infrastructure may, in addition to the actual rainwater, collect and store harmful pollutants.

Furthermore, although some RWH features such as rooftops present harmful prospects, such as the inclusion of bird droppings into the harvested rainwater, people are generally more likely to frown upon the use of greywater, as opposed to rainwater, to supplement potable water uses. This could be another possible explanation for the differences in preferences, or rather perceived barriers to implementation, between respondents from Australia and Barcelona (Spain). Therefore, it is imperative to ensure that homeowners, and household members alike, have access to information on both the advantages and disadvantages of various WSUD measures, as well as appropriate end-uses of alternative sources of water, in order to shape individual perceptions, which (as argued earlier) ultimately influence people's attitudes; as well as to consequently promote the optimal use of selected WSUD measures.

In addition to enhancing awareness levels among water users, subjective norms (as highlighted earlier) have also been reported to shape individual perceptions. For example, participants from an interview study by Dzidic and Green (2012) reported the existing pressure to out-do their neighbours concerning home and household aesthetics (Dzidic & Green, 2012). As a result, their willingness to invest in sustainable urban design, or more specifically WSUD measures, was likely to be shaped by what the neighbourhood deemed as aesthetically trendy or perceived as *a norm* when the study was conducted. With regards to their particular case study, Dzidic and Green (2012) observed that although participants from suburban Australia were receptive to using greywater for watering their lawns, they were more willing and likely to invest in green lawns and alien vegetation, which generally require substantial amounts of water for maintenance, as opposed to native as well as drought and water-resistant surfaces and vegetation; and that this was as a result of subjective neighbourhood norms (Dzidic & Green, 2012).

Moreover, as informed by findings from their research, Dzidic and Green (2012) suggest that in order to encourage the adoption of sustainable practices and technologies – social norms need to be challenged and that it is imperative to ultimately present households in such neighbourhoods with opportunities to compete over the 'greenest', 'most sustainable, or in this case, most 'water sensitive' housing design, as opposed to just competing over the greenest lawn (Dzidic & Green, 2012).

2.3.3 Physical and Contextual Factors

The factors associated with the physical and contextual aspects of households were also identified as one of the sets of factors found to have an influence – i.e. in the existing body of knowledge – on the uptake of selected WSUD measures by urban households. As part of this set of factors, a household's access to municipal (i.e. reliable, regular and usually centralised potable) water supply, and a household's spatial capacity to install, retrofit, operate and/or maintain the infrastructure or technology associated with the measures in question – including a household's capacity to store the generated rain or greywater in particular – are argued to influence the household uptake of selected WSUD measures, i.e. RWH, PP and GWR (Pinto & Maheshwari, 2010; Gilbertson et al., 2011; Cote & Wolfe, 2014; Owusu & Teye, 2015; Brown et al., 2016; Mason et al., 2018). These factors are discussed in detail below.

2.3.3.1 Access to Municipal or Centralised [Potable] Water Supply and Spatial and Storage Capacity

As part of their study outlining residents' expressed social and economic objections to permeable surfaces, Cote and Wolfe (2014) note the following:

> "Potential barrier examples include adopters' *physical capacity*, knowledge, awareness, attitudes and perceptions; expense; uncertainty; and risk levels associated with the technical innovation" (Cote & Wolfe, 2014, p. 9, ***emphasis mine***)

Furthermore, in addition to their dislike of the appearance of tanks, participants from the LSC (i.e. Little Stringybark Creek) retrofit project – which, as highlighted earlier, involved providing residents with incentivised rain barrels (tanks) and rain gardens – expressed their concern for the potential loss of domestic recreational space, as imposed by the water infrastructure associated with the measures in question (Brown et al., 2016). Therefore, these measures provide households based in high rise, multi-family buildings with limited enabling options for taking up the measures themselves.

Regarding households' access to centralised or municipal water services, qualitative findings from a Philippines case study by Mason et al. (2018) suggest that a household's water insecurity can result in the [supplementary] use of both rainwater and greywater. For example, Mason et al. (2018) observed that respondents' lack of access to *basic water distribution* (BWD) was associated with their domestic use of rainwater during rainy and dry seasons. Furthermore, their quantitative findings revealed that households without any access to BWD were 1:72 times more likely to harvest greywater when compared to those with access to either shared or other forms of BWD (Mason et al., 2018). Owusu and Teye (2015) witnessed similar findings in their study on challenges related to household RWH; whereby residents were, to some extent, compelled to utilise rainwater, as well as other alternative sources of water, as a result of limited access to centralised water supplies in the peri-urban areas of Accra, Ghana (Owusu & Teye, 2015).

2.3.4 Situational and Behavioural Factors

Three factors related to households' – or water users' – situational and behavioural aspects, which have been found to influence pertinent households' uptake of selected WSUD measures, were identified during the review process. These include the introduction and enforcement of water use restrictions, an individual's or household's existing pro-environmental, or rather water-saving behaviour, as well as a households' proximity to water challenges such as water scarcity (Pinto & Maheshwari, 2010; Mankad & Tapsuwan, 2011; Brown et al., 2016; Campisano et al., 2017; Schirmer & Dyer, 2018). As featured in the published literature, the key arguments related to each of these factors are highlighted below.

2.3.4.1 Pro-Environmental Behaviour

Below are some definitions of *pro-environmental behaviour*, as provided for in the existing body of knowledge:

> "Defining 'Behaviour'…any active responsiveness to current environmental issues, believed to be pro-environmental by the person performing the response." (Eilam & Trop, 2012, p. 2212)

> "Environmental behaviour is defined as the complex of activities informed by a concern for future generations, other species, or the whole ecosystem." (Du et al., 2018, p. 3 of 24)

As such, for the purposes of this study, an individual's, or household's, pro-environmental behaviour refers to an individual's, or household's, ability to take up any of the selected WSUD measures, i.e. RWH, PP and GWR, as a result of their concern for and consequent reaction or response to the relevant environmental issues, i.e. environmental issues related to the quality and quantity of water. Therefore, as informed by the existing body of knowledge, a household member's, or members', extant pro-environmental behaviour, in the form of existing water-saving behaviour, was identified as a behavioural factor and has, in some cases, been found to influence households' uptake of selected WSUD measures (Bjornlund et al., 2013; Schirmer & Dyer, 2018; Amodeo & Francis, 2019).

For instance, in their study examining the potential opportunities for incentivising private landowners to make improvements aimed at retaining stormwater or slowing its conveyance to waste and stormwater infrastructure, Amodeo and Francis (2019) note the following:

> "Two further studies found that self-identifying environmentally friendly consumers will make consumption and purchase decisions that are "greener" in the absence of outside incentives across a broad spectrum of daily practices and purchase decisions." (Amodeo & Francis, 2019, p. 297)

Moreover, in their Australian study on factors influencing pro-environmental behaviours associated with WSUD, Schirmer and Dyer (2018) found that respondents who embraced *pro-environmental values* related to water conservation were more likely to engage in gardening practices that protect the quality of stormwater and receiving water bodies. Similarly, these existing water conservation values were found to be a significantly strong predictor of water sensitive gardening practices (Pinto & Maheshwari, 2010; Gilbertson et al., 2011; Bjornlund et al., 2013; Zou et al., 2015; Campisano et al., 2017; Schirmer & Dyer, 2018; Amodeo & Francis, 2019). Furthermore, in their Canadian study on water user policy preferences for water sharing in Canada, Bjornlund et al. (2013) discovered that younger as well as better educated individuals with liberal political views were more likely to have a greater level of environmental concern and that income levels as well as gender and education were the strongest predictors of pro-environmental values… (Bjornlund et al., 2013). As outlined, several socio-economic factors, including age, gender, political views, level of education and income, have been found to influence water users' *pro-environmental values*, which according to Gatersleben et al. (2014), "play a role in explaining and predicting environmental behaviour" (Gatersleben et al., 2014, p. 376). Pro-environmental values are defined as:

> "…concepts and beliefs, [about] desirable end states or behaviours [i.e. pro-environmental behaviour], [which] transcend specific situations, [and] guide selection or evaluation of behaviour and events, and are ordered by relative importance" (Gatersleben et al., 2014, p. 377)

As such, examining the influence that these socio-economic factors might have on the urban household uptake of selected WSUD measures, i.e. RWH, PP and GWR, might benefit this study.

2.3.4.2 Proximity to Water Challenges

A household's proximity to water challenges emerged as a central factor influencing the uptake of selected WSUD measures, as well as the advancement of sustainable domestic practices in general (Pinto & Maheshwari, 2010; Gilbertson et al., 2011; Zou et al., 2015; Schirmer & Dyer, 2018). For example, according to Schirmer and Dyer (2018):

> "A person's proximity to an environmental problem in both space and time affects their likelihood of acting to address that problem, with action more likely for proximal issues than those perceived as occurring a distance away" (Schirmer & Dyer, 2018, p. 7692)

Schirmer and Dyer (2018) further discern that residents living closer to waterways are characterised by greater awareness of water quality issues and that residents living in areas experiencing water scarcity are related to greater adoption of water conservation behaviours (Schirmer & Dyer, 2018). Moreover, they found that a respondent's attachment to an area – or as they term it, *recreational proximity*, in the form of relating to or frequently spending time recreating around an area's water bodies and watercourses – was a much stronger predictor of uptake than residential (or local) proximity (Schirmer & Dyer, 2018). Similarly, in an Australian case study investigating the impact of an area's water situation – particularly water availability – on inhabitants' attitudes toward water conservation, as well as their reported involvement in water conservation behaviours, Gilbertson et al. (2011) found that significantly more respondents from a water-scarce region were supportive of water conservation behaviours when compared to respondents from a region with a water surplus (Gilbertson, et al., 2011). Thus, relatively more respondents from the former (i.e. water-scarce) region affirmed their engagement in most water conservation activities than those residing in the latter (i.e. water-secure) region (Gilbertson et al., 2011).

Similarly, 92% of participants from Pinto and Maheshwari's (2010) study indicated further use of greywater when asked about what they would do to cope with water scarcity in their region (Pinto & Maheshwari, 2010). As a result, it was deduced that people tend to look for alternative water sources when faced with water scarcity (Pinto & Maheshwari, 2010). However, both Owusu and Teye (2015), as well as Valles-Casas, et al. (2016), warn of the unreliability of RWH, particularly intending to use harvested rainwater to meet potable water needs during periods of drought (Owusu & Teye, 2015; Valles-Casas et al., 2016). GWR, on the other hand, is reliable throughout the year as its availability, as mentioned earlier, is dependent on household water use practices and the amount of greywater generated by the pertinent households (Owusu & Teye, 2015; Valles-Casas et al., 2016; Nel et al., 2017).

In their (2015) study exploring the values people assign to water, and their preferences for water re-allocation policies, Zou et al. (2015) refer to *period effects*, which is a term they use to describe particular events that can shape environmental values and policy preferences (Zou et al., 2015). Using the United States of America (USA) as an example, Zou et al. (2015) argue that period effects explain most of the observed change in environmental values and policy preferences. However, they also draw attention to the temporary and, sometimes inconsistent, nature of period effects:

> "Specific environmental events can shape environmental values and policy preferences and *these may not be maintained after the event*…" (Zou et al., 2015, p. 5075, ***emphasis mine***)

> "It is also possible that period effects mean that values and preferences are expressed in inconsistent ways. For example, it is possible that the younger generation have grown up at a time when there has been much public discussion of climate change, which may predispose them to valuing the environment." (Zou, et al., 2015, p. 5085)

2.3.4.3 Water Use Restrictions

Water use restrictions also emerged in existing literature as one of the factors influencing the household uptake of selected WSUD measures (Pinto & Maheshwari, 2010; Fisher-Jeffes et al., 2017; Nel et al., 2017). Hence, for the purpose of this study, water use restrictions are identified as a *situational* factor. As discussed earlier, water use restrictions refer to instruction mandates that typically place limitations on which – and on when certain types of – water use activities households and water users may engage in (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014).

As such, in terms of water use restrictions, Campisano et al. (2017) note that in 2007 about 24% of Australian households had fitted rainwater tanks in their homes and that the number increased to 34% in 2013; it is argued that this increase was relatively attributed to water restrictions imposed by both government and water authorities (Campisano et al., 2017). Furthermore, Pinto and Maheshwari (2010) discovered that the ability for households to maintain lawns and gardens was affected by restrictions on potable water use for irrigation and that homeowners were compelled to look for alternative water supplies such as GWR (Pinto & Maheshwari, 2010).

2.3.5 Socio-demographic Factors

Several socio-demographic factors that have been found to influence the urban household uptake of selected WSUD measures – including RWH, PP and GWR – were also identified while reviewing existing literature. These include household income, household size, as well as a domestic water user's level of education, age, and gender, and a household's security of tenure, or rather home-ownership status (Booth & Leavitt, 1999; Pinto & Maheshwari, 2010; Gilbertson et al., 2011; Mankad & Tapsuwan, 2011; Barthwal et al., 2014; Cote & Wolfe, 2014; Baiyegunhi, 2015; Garcia et al., 2015; Owusu & Teye, 2015; Zou et al., 2015; Brown et al., 2016; Valles-Casas et al., 2016; Fisher-Jeffes et al., 2017; Mason et al., 2018; Schirmer & Dyer, 2018). The main assertions concerning each of these factors are outlined below.

2.3.5.1 Household Income

As highlighted above, household income emerged as one of the factors that have been found to have an influence on the uptake of RWH, PP and GWR by the relevant households (Pinto & Maheshwari, 2010; Mankad & Tapsuwan, 2011; Barthwal et al., 2014; Cote & Wolfe, 2014; Baiyegunhi, 2015; Fisher-Jeffes et al., 2017). For instance, both Barthwal et al. (2014) and Baiyegunhi (2015) found people's willingness to invest in RWH systems being positively influenced by their respective household income, while Mankad and Tapsuwan (2011) noted that a household's ability to adopt an alternative water system is typically limited by that household's income (Mankad & Tapsuwan, 2011; Barthwal et al., 2014; Baiyegunhi, 2015).

Moreover, findings from a study by Cote and Wolfe (2014) revealed that households with higher incomes were willing to spend more money on the uptake and installation of permeable surfaces than were those with low or medium household incomes (Cote & Wolfe, 2014); they further argue that although higher-income households are willing to spend more, installation costs of permeable surfaces remain a major barrier to their adoption (Cote & Wolfe, 2014). Results from Barthwal et al.'s (2014) study illustrate this insight as they observed the following:

> “. . .respondents in the highest income class [were] willing to invest relatively more money in RWH systems for their households than their counterparts. Furthermore, respondents who earned the least indicated that they wanted financial assistance, either full or partial, from the government” (Barthwal et al., 2014, p. 237)

Therefore, respondents' household income and [their] consequent ability to afford the selected measures, due to their cost, influenced their intent [or willingness] to invest in the measures in question.

This factor, as highlighted by Cote and Wolfe (2014), is mostly triggered by the costs associated with the measures, which are often found to be relatively expensive (Booth & Leavitt, 1999; Pinto & Maheshwari, 2010; Mankad & Tapsuwan, 2011; Barthwal et al., 2014; Cote & Wolfe, 2014; Brown et al., 2016). For instance, Booth and Leavitt (1999) argue that although permeable pavement types vary widely in cost, all available types are more expensive than asphalt, which is a type of impermeable surface that is typically installed in developed areas; they further argue that justifying the installation of permeable surfaces on economic grounds alone, often proves difficult (Booth & Leavitt, 1999). Similarly, according to Fisher-Jeffes, et al. (2017), “international experience also suggests that RWH is a relatively expensive alternative water resource…which may make it inappropriate for poorer communities” (Fisher-Jeffes et al., 2017, p. 81).

Moreover, Mankad and Tapsuwan (2011) argue that upfront establishment and retrofitting costs associated with the introduction of decentralised domestic water systems, including RWH and GWR systems, are usually high and that these are likely to deter homeowners from installing a supplementary water system; while Pinto and Maheshwari (2010) note that respondents considered the costs associated with the installation of greywater plants ahead of adopting GWR as a domestic practice (Pinto & Maheshwari, 2010; Mankad & Tapsuwan, 2011).

Notably, in response to the limitations imposed by the costs associated with the installation or adoption of selected WSUD measures, particularly with regards to RWH and GWR systems, Valles-Casas et al. (2016) suggest the creation of new rates, or an increment of existing rates, in potable water taxation, i.e. to make these measures economically competitive with centralised potable water supplies (Valles-Casas et al., 2016).

2.3.5.2 Household Size

Household size, particularly the total number of members in a household, has been found to influence the adoption of some of the selected WSUD measures; with larger households argued as likely to adopt the measures to secure alternative sources of water to meet the demand generated by the sizeable members (Mason et al., 2018). For instance, in addition to a households' financial resources, i.e. household income, and their access to BWD (i.e. basic water distribution), Mason et al. (2018) also found significant associations between greywater use and household size. Furthermore, results from the same study led them to the following conclusion:

> "Results suggest that rainwater may be a particularly valuable coping strategy for large or low-income households and those with limited access to the public [water] utility. Larger households likely have higher absolute water needs, and may have less income or savings from water expenses as financial resources are spread among more household members" (Mason et al., 2018, p. 113)

Therefore, the key argument presented by Mason et al. (2018) is that a household's size, i.e. sizeable households, in particular, coupled with the relevant households' limited access to potable water supply, usually as a result of a constrained household income or general lack of services, is likely to encourage the adoption of some of the measures in question, i.e. by the pertinent households; all in an effort to secure enough water from a wide range of sources, in order to meet the demand (Mason et al., 2018).

2.3.5.3 Education

Another factor that was identified as a possible (and in some instances proven) predictor of the urban household uptake of the measures in question is *education* (Bjornlund et al., 2013; Baiyegunhi, 2015; Garcia et al., 2015; Schirmer & Dyer, 2018). Based on the premise that individuals who are relatively more educated are likely to adopt pro-environmental behaviour (which includes the uptake of the measures in question) as a result of their implicit exposure to knowledge about the environment, which is inclusive of water as well as its challenges and associated tactics, i.e. environmental awareness – an individual's level of education is perceived, by some scholars, as a predictor, or rather an influential factor when it comes to the urban household uptake of selected WSUD measures, as well as the consequent use of alternative sources of water (Bjornlund et al., 2013; Baiyegunhi, 2015; Garcia et al., 2015; Schirmer & Dyer, 2018).

For instance, as part of a study by Baiyegunhi (2015), education was revealed to have a positive and statistically significant effect on the household uptake of RWH technology, meaning that educated individuals were more likely to adopt RWH technology (Baiyegunhi, 2015). On the contrary, Garcia et al. (2015) adopted a premise similar to the one outlined above; however, the results were inconsistent with their hypothesis; below is a possible explanation for this occurrence, as provided for by Garcia et al. (2015):

> "Despite the hypothesis that higher-educated individuals will be more likely to own an alternative source of water for their garden because they might display greater environmental awareness, the results reported an inverse [negative] and significant relationship … this result can depict an interestingly generational trend in the behaviour of the gardeners. The higher-educated group of inhabitants is generally represented by young city-born…folk who have no rural roots. On the contrary, the less-educated older inhabitants might share a rural background that could explain their frequent adoption of alternative sources of water" (Garcia et al., 2015, p. 560)

Taking note of Garcia et al.'s (2015) argument, another reason for this occurrence could simply be that the urban respondents from Garcia et al.'s (2015) study may also be members of households in upmarket, i.e. high-income, areas who do not want to compromise aesthetics, which may be imposed by the measure(s) in question, or who think that they can always pay for water no matter the costs.

2.3.5.4 Age

An individual's or water user's age also featured among the socio-demographic factors found to influence the domestic uptake of selected WSUD measures (Barthwal et al., 2014;

Baiyegunhi, 2015; Garcia et al., 2015; Zou et al., 2015). For example, in their study, which outlines the development of a framework designed to guide identifying factors that are likely to influence the adoption of pro-environmental behaviours associated with WSUD, Schirmer and Dyer (2018) introduced what they refer to as the Values and norms, Awareness, Identity, Lifestyle and life stage (VAIL) framework (Schirmer & Dyer, 2018). As such, existing studies were synthesized, which resulted in the identification of four (or sets) domains of factors that are likely to influence the adoption of WSUD-relevant pro-environmental behaviours (Schirmer & Dyer, 2018). The identified domains include the following:

- "Pro-environmental *values and norms*, which consist of the endorsement and enactment of social norms that are consistent with the protection of water resources;
- Environmental *awareness* and knowledge, which refers to a person's, or people's, awareness of an environmental problem, as well as awareness about how their actions can either cause or address the problem;
- Factors related to a water user's *Identity, i.e. proximity and place-based attachment*, which stems from a person's interaction with water resources through aspects such as residence, consumption, work and recreation, as well as a person's connection to water resources, i.e. a person's cultural, aesthetic, economic, or social attachment to water resources; and
- Factors related to a water user's *Lifestyle and life stage*, which are based on the premise that acting to protect water is compatible with and given similar priority to other life objectives, and that socio-demographic characteristics such as age, home-ownership and gender facilitate action" (Schirmer & Dyer, 2018, p. 7692).

As a result, the VAIL framework was applied to an Australian based survey study that measured the awareness and perceived impact of homeowners' gardening practices on the water quality of receiving or proximate water bodies. In terms of *Lifestyle and life stage* factors, a respondent's home-ownership status and *age* emerged as an influential factor as Schirmer and Dyer (2018) deduced that individuals who owned their homes, as well as older people, were more likely to adopt and engage in water sensitive gardening practices, that is when compared to tenants and younger people respectively (Schirmer & Dyer, 2018).

Conversely, in their Canadian based study exploring the values that people assign to water and their preferences for water re-allocation policies, Zou et al. (2015) discovered that younger respondents valued the environmental use of water and, as a result, preferred water re-allocation, i.e. water reuse, policies which offer greater environmental protection (Zou et al., 2015).

2.3.5.5 Gender

Gender, or rather a water user's gender, constitutes another factor that has been argued, and in some cases found, to influence an individual's, or household's, uptake of selected WSUD measures (Brown & Davis, 2007; Pinto & Maheshwari, 2010; Garcia et al., 2015; Mason et al., 2018). For instance, in a study by Brown and Davis (2007), both gender and cultural background were revealed to be statistically significant predictors of domestic rainwater and greywater reuse for a community in Northern Sydney; while a survey study by Pinto and Maheshwari (2010) indicated that greywater was domestically reused by more females than males (Brown & Davis, 2007; Pinto & Maheshwari, 2010).

In contrast, quantitative results from Mason et al.'s (2018) study found no association between the gender of the water manager, which refers to a household member who is responsible for overseeing water use practices in his or her household, and the use of greywater or rainwater (Mason, et al., 2018). However, the qualitative findings from the [same] study's in-depth interviews suggest that women, as opposed to men, may have been more likely to conserve water through GWR as a result of their relatively continuous presence in the home, which enables them to observe and, in some cases, mitigate unsustainable domestic water use practices (Mason et al., 2018). Similarly, various other scholars argue that people who spend relatively more or most of their time at home – such as unemployed or retired individuals, and [in areas or households characterised by traditional gender roles] women – are more likely to support, encourage, engage in and adopt sustainable water use practices, which are inclusive of the uptake of the measures in question (Brown & Davis, 2007; Garcia et al., 2015; Mason et al., 2018). Therefore, as opposed to an individual's gender, this position recognises an individual's ties to the home [or the amount of time an individual or water user is likely to spend at home] as an influential factor with regards to taking up sustainable water use practices, as well as selected WSUD measures (Brown & Davis, 2007; Garcia et al., 2015). Similarly, results from a study by Garcia et al. (2015) revealed that a large[r] percentage of unemployed or retired household members had adopted alternative water sources for gardening and irrigation purposes, including RWH (Garcia et al., 2015).

2.3.5.6 Ownership Status

A household's home-ownership status emerged as one of the factors found to influence the uptake of selected WSUD measures (Pinto & Maheshwari, 2010; Baiyegunhi, 2015; Owusu & Teye, 2015; Schirmer & Dyer, 2018). For instance, in their study examining challenges to investing in RWH infrastructure in the peri-urban areas of Accra (Ghana), Owusu and Teye (2015) note that a majority of the households that had invested in RWH infrastructure were owner-occupied; with 48.9% of households with RWH technology being owner-occupied, while tenants occupied only 13% of households with RWH technology. Furthermore, approximately 65% of households without RWH facilities identified *short-term tenancy arrangements* as a major hindrance to investment in RWH infrastructure (Owusu & Teye, 2015). With regards to GWR, Pinto and Maheshwari (2010) observed the following:

> "One survey participant, who lives in a rental property, was unable to reuse or install the greywater system because the landlord did not want it. Another one said the landlord refuses this idea because future tenants may not be committed to the greywater reuse [system] and the investment is unlikely to be economically viable" (Pinto & Maheshwari, 2010, p. 148)

This further indicates the limitations faced by tenant households when it comes to taking up selected WSUD measures.

2.3.6 Institutional Arrangements

Institutional arrangements, which are defined by the United Nations Committee of Experts on Global Geospatial Information Management as "the policies, systems, and processes that organisations use to legislate, plan and manage their activities efficiently and to effectively coordinate with others in order to fulfil their mandate." (United Nations, 2020, p. online source), were also identified among the various set of factors that have been found to influence the urban household uptake of selected WSUD measures. These 'mandates' are often facilitated by government and water authorities to promote and ensure the adoption or uptake of water conservation practices, as well as the measures in question, and to support households, or individuals, that adopt them. As such, for the purpose of this study, economic (i.e. financial) incentives and legislative mandates constitute the primary factors that were identified under the set of institutional arrangements (Parsons et al., 2010; Domenech & Sauri, 2011; Fewkes, 2012; Mayer et al., 2012; Barthwal et al., 2014; Cote & Wolfe, 2014; Brown et al., 2016; Valles-Casas et al., 2016; Ahammed, 2017; Campisano et al., 2017; Nel et al., 2017; Charalambous et al., 2018). The key arguments regarding the influence of economic incentives and legislative mandates on the household uptake of selected WSUD measures by urban households are highlighted below.

2.3.6.1 Economic Incentives

As highlighted earlier, economic, or financial, incentives were identified as a factor that may, and in some cases has been found to influence the urban household uptake of selected WSUD measures (Parsons et al., 2010; Domenech & Sauri, 2011; (Fewkes, 2012) Mayer, et al., 2012; Barthwal et al., 2014; Cote & Wolfe, 2014; Brown et al., 2016; Valles-Casas et al., 2016; Ahammed, 2017; Campisano et al., 2017; Charalambous et al., 2018). In this case, economic incentives are intended to encourage and promote households' uptake of selected WSUD measures.

Examples of countries that have introduced incentives to encourage the domestic uptake and use of some of the selected WSUD measures include the following:

- Germany, whereby RWH adoptees are exempt from paying stormwater taxes;
- Australia, whereby rebates of up to 500$ are offered to households installing an RWH system; as well as
- the USA (Texas), whereby RWH equipment is exempted from sales tax (Domenech & Sauri, 2011; Fewkes, 2012; Charalambous et al., 2018)

Moreover, regarding RWH systems, Fewkes (2012) maintains the following:

> "Texas is an example of a state which has experienced growth in the use of RWH systems over the past ten to 15 years where it is estimated 15 000 systems are now in operation. The growth is related to climatic conditions and continuing population growth but has been further assisted by governmental incentives and improved literature relating to the design and operation of systems" (Fewkes, 2012, p. 176)

Furthermore, in addition to the apparent benefits generated by economic incentives, such as savings in infrastructure costs, various studies have established their relevance as a factor capable of influencing a households' decision to take up selected WSUD measures. For instance, 83% of respondents from a study by Barthwal et al. (2014) indicated their willingness to invest in rooftop RWH systems for their households; however, 89% required government incentives to assist them in acquiring and installing the systems in their respective households (Barthwal et al., 2014). Moreover, about 40% of participants from a study by Domenech and Sauri (2011) selected *'installation grants/subsidies'* as one of the factors that would most likely improve their receptiveness to RWH (Domenech & Sauri, 2011; Ahammed, 2017). However, some of the participants from the latter study admitted that they would have installed the system without support from authorities (Domenech & Sauri, 2011). Domenech and Sauri (2011) ascribe this observation to respondent's high level of environmental awareness; although, high-income levels may well have been a contributing factor (Domenech & Sauri, 2011). Mayer et al. (2012) also verified the viability of incentives, in the form of free rain gardens and rain barrels, to encourage the implementation of sustainable stormwater management practices on private properties; while respondents from a study by Cote and Wolfe (2014) indicated a willingness to spend more on permeable surfaces, or PP, if municipal incentive were to be provided (Mayer et al., 2012; Cote & Wolfe, 2014).

2.3.6.2 Legislative Mandates

Another factor that has been identified as a type of institutional arrangement that has also been found to influence the uptake of selected WSUD measures is that of legislative mandates (Parsons et al., 2010; Domenech & Sauri, 2011; Fewkes, 2012; Valles-Casas et al., 2016; Ahammed, 2017). Legislative mandates constitute one of the few factors of WSUD uptake that have no association with user acceptance. These typically involve the obligatory and compulsory adoption, installation or uptake of the measures in question; thus, a household's or domestic water user's willingness to take up the relevant measure(s) becomes irrelevant. As such, taking the concept of user acceptance into consideration, the mandatory aspect of legislative mandates presents a potential limitation to the effectiveness of the measure(s) that water users are obligated to take up. Using RWH as an example, Mukheibir et al. (2014) note the following:

> "…literature (on rainwater tank maintenance activities) also suggests that voluntary rainwater tank owners are more motivated and hence more likely to maintain their system than those who have been forced to install one because of regulations" (Mukheibir et al., 2014, p. 382)

According to Fewkes (2012), "legislation is one of the principal levers which can be used to drive or limit water demand management and in particular RWH" (Fewkes, 2012, p. 186). Furthermore, using municipal by-laws as an example, Nel et al. (2017) outline the enforcement procedure of a legislative mandate for RWH and GWR:

> "A municipality [follows] the necessary procedures by which by-laws have been put in place, thus regulating the registration of such use – in such a case a homeowner may be required to register, with potential consequences should the homeowner fail to comply." (Nel, et al., 2017, p. 557)

As such, for the purposes of this study, legislative mandates refer to legislative mechanisms, policies or regulations that mandate households and various other water users to install or take up selected WSUD measures, which include RWH, PP and GWR. Usually applicable to both existing (brownfield) and new (greenfield) developments, legislative mandates have been found to influence the adoption of WSUD measures in urban households (Parsons et al., 2010; Domenech & Sauri, 2011; Fewkes, 2012; Valles-Casas et al., 2016; Ahammed, 2017).

For instance, Domenech and Sauri (2011) identify both regulations and subsidies as effective strategies to advocate for and expand the installation and use of RWH systems in residential areas (Domenech & Sauri, 2011). They particularly make note of authorities in Barcelona (Spain) that apply regulations to mandate the installation of RWH systems in new buildings while offering incentives, in the form of financial subsidies, to promote the installation of the pertinent systems in existing buildings (Domenech & Sauri, 2011; Valles-Casas et al., 2016; Ahammed, 2017).

Moreover, in a study investigating the barriers faced by UK (i.e. United Kingdom) home building companies when it comes to including RWH systems in new developments, Parsons et al. (2010) note that out of a total of 46 respondents, 44 identified '*new and clearer legislation governing RWH systems'* as a component that would aid them in taking up the system for [or as part of] future developments (Parsons et al., 2010; Fewkes, 2012)**.** Similarly, Fewkes (2012) identified institutional and regulatory control as some of the factors influencing the household uptake of RWH in the UK (Fewkes, 2012).

Notably, Valles-Casas et al. (2016) identified an additional factor that is related to institutional arrangements. This factor emerges as an extension of legislative mandates and is referred to as *active and continuous political will* (Valles-Casas, et al., 2016). Below is a description of this subfactor, as defined by Valles-Casas et al. (2016):

> "If many regulations and norms fail or do not fulfil all the potential of these [RWH and GWR] technologies, it is precisely because while there is political will to draft and launch an initiative, this is forgotten some months later and shelved. The costly and difficult process is not only to draft a policy and pass a law, but to open it to periodical reviews and amendments, making it alive and coevolving with the context where it is embedded, i.e. adapting the policy to technological changes, to new environmental pressures and/or to changing societal needs, preferences and perceptions" (Valles-Casas et al., 2016, p. 253).

Therefore, in addition to the continual maintenance of the infrastructure, or systems, associated with the measures, i.e. by relevant stakeholders – active and continuous engagement by authorities, in the form of policy enforcement, monitoring, reviewing and modifications is necessary to increase the viability of the measures in question, as well as to improve the influential capability of legislative mandates when it comes to advancing the household uptake of selected WSUD measures.

2.3.7 Summary: Factors Influencing the Uptake of Selected Water Sensitive Urban Design Measures

As illustrated in Figure 6(a), 16 factors that have been found to influence households' decision to take up selected WSUD measures – including RWH, PP and GWR – were identified while reviewing the relevant literature. These were organised into six sets, which include factors related to *awareness*, a household's or domestic water user's *attitudes*, *physical and contextual* factors, *situational and behavioural* factors, *socio-demographic* factors, and *institutional arrangements*. Under *awareness*, environmental awareness and awareness about the purpose, use, and benefits of selected WSUD measures were identified. Moreover, household attitudes towards selected WSUD measures were identified under *attitudes*. Regarding *physical and contextual* factors, a household's access to municipal or centralised [potable] water supply and a household's spatial and storage capacity were identified. Under *situational and behavioural* factors, a water user's pro-environmental behaviour, a household's proximity to water challenges, and water use restrictions were identified; while *socio-demographic* factors include household income, household size, education, age, gender and [home] ownership status. Lastly, legislative mandates and economic incentives were identified under *institutional arrangements*.

Therefore, to conclude this section of the literature review, Table 4 below summarises the key findings in the literature on factors influencing the household uptake of selected WSUD measures by outlining the factors in question, together with the key hypothesis behind each factor, as well as studies in the literature whereby findings either (*i*) support or (*ii*) do not support the main hypothesis.

Table 4: Hypotheses behind the factors influencing the household uptake of Water Sensitive Urban Design measures

Factors	Hypothesis	Literature supporting the hypothesis	Literature not supporting the hypothesis
Awareness			
Environmental Awareness	Water users that demonstrate high levels of environmental awareness are more likely to adopt pro-environmental behaviour, which is inclusive of the household uptake of selected WSUD measures.	Noiseux & Hostetler, 2010 Hayden, et al., 2015 Schirmer & Dyer, 2018	*
Awareness of WSUD Measures	Water users that are aware of selected WSUD measures, as well as the benefits and roles of the relevant measures in terms of addressing water challenges are more likely to adopt or take up the measures in question.	Cote & Wolfe, 2014 Barthwal et al., 2014	*
Attitudes			
Attitudes towards selected WSUD measures, i.e. GWR, RWH and PP	A water user's *positive attitudes* towards selected WSUD measures – which are typically fuelled by the perceived benefits associated with the relevant measures, such as savings on water bills, resilience from water shortages or water use restrictions, and environmental conservation - are likely to drive respondents to take up the measures in question.	Domenech & Sauri, 2011 Mankad & Tapsuwan, 2011 Valles-Casas, et al., 2016 Campisano, et al., 2017	*
	A water user's negative attitudes towards selected WSUD measures – which usually stem from the perceived costs of taking up the relevant measures, such as perceived installation or retrofit costs, perceived maintenance commitments, and perceived health and investment risks – are likely to act as barriers to taking up the measures in question.	Brown & Davis, 2007 Pinto & Maheshwari, 2010 Mankad & Tapsuwan, 2011 Ward et al., 2013 Barthwal et al., 2014 Chowdhury et al., 2015	*

Table 4: Hypotheses behind the factors influencing the household uptake of Water Sensitive Urban Design measures

Factors	Hypothesis	Literature supporting the hypothesis	Literature not supporting the hypothesis
Physical and Contextual Factors			
Access to Municipal or Centralised [Potable] Water Supply and	Households with a lack of, or limited, access to municipal and/or centralised (i.e. reliable) potable water supply are more likely to take up selected WSUD measures, particularly RWH and GWR, as a means to generate and secure water from alternative sources.	Owusu & Teye, 2015 Mason et al., 2018	*
Spatial and Storage Capacity	Households with the capacity to install, retrofit, operate and/or maintain the infrastructure and technology associated with selected WSUD measures are more likely to take up the measures in question.	Cote & Wolfe, 2014 Brown et al., 2016	*
Situational and Behavioural Factors			
Pro-Environmental Behaviour	Domestic water users that exhibit pro-environmental behaviour are relatively more likely to take up selected WSUD measures than those without existing pro-environmental behaviour.	Schirmer & Dyer, 2018 Amodeo & Francis, 2019	*
Proximity to Water Challenges	Water users in close proximity to environmental challenges such as water shortages and poor water quality are relatively more likely to take up selected WSUD measures to address the challenges than those that find themselves isolated or detached from the same, or similar, challenges.	Pinto & Maheshwari, 2010 Gilbertson, et al., 2011 Zou, et al., 2015 Schirmer & Dyer, 2018	*
Water Use Restrictions	Households affected by water use restrictions are more likely to take up selected WSUD measures, particularly RWH and GWR, to minimise the impact thereof.	Pinto & Maheshwari, 2010 Campisano et al., 2017	*

Table 4: Hypotheses behind the factors influencing the household uptake of Water Sensitive Urban Design measures

Factors	Hypothesis	Literature supporting the hypothesis	Literature not supporting the hypothesis
Socio-demographic Factors			
Household Income	Households with relatively higher incomes are more likely to adopt or take up selected WSUD measures than those with relatively lower household incomes.	Barthwal et al., 2014 Cote & Wolfe, 2014 Baiyegunhi, 2015	*
Household Size	Larger households are more likely to take up selected WSUD measures, particularly RWH and GWR, to secure alternative water sources to meet the demand generated by the respective sizeable household members, i.e. compared to households with relatively smaller amounts of members.	Mason et al., 2018	*
Education	Highly educated individuals are more likely to adopt pro-environmental behaviour, which includes the uptake of selected WSUD measures, i.e. compared to relatively less-educated individuals or water users.	Baiyegunhi, 2015	Garcia et al., 2015
Age	Relatively older people, i.e. water users, are more likely to adopt pro-environmental behaviour, including the household uptake of selected WSUD measures, i.e., compared to their counterparts (relatively younger water users).	Schirmer & Dyer, 2018	Zou et al., 2015
Gender	Females, including female-headed households and predominantly female households, are relatively more likely to take up selected WSUD measures, i.e. RWH and GWR, than males.	Brown & Davis, 2007 Pinto & Maheshwari, 2010 Mason et al., 2018	Mason et al., 2018
Ownership Status	Domestic water users that own their homes are relatively more likely to take up selected WSUD measures than those who do not, i.e. tenants.	Pinto & Maheshwari, 2010 Owusu & Teye, 2015	*

Table 4: Hypotheses behind the factors influencing the household uptake of Water Sensitive Urban Design measures

Factors	Hypothesis	Literature supporting the hypothesis	Literature not supporting the hypothesis
Institutional Arrangements			
Economic Incentives	Households with access to incentivised opportunities to take up selected WSUD measures are more likely to take up the measures as a result.	Domenech & Sauri, 2011 Mayer et al., 2012 Barthwal et al., 2014 Cote & Wolfe, 2014	*
Legislative Mandates	Households that are [legally] obligated to take up selected WSUD measures are highly likely to take them up.	Parsons et al., 2010 Fewkes, 2012	*

As illustrated in Table 4, with the exception of some socio-demographic factors – including education, age, and gender – the literature seems to agree regarding the influence of most factors on the household uptake of selected WSUD measures. Moreover, it is important to note that literature on the factors influencing the household uptake of PP is limited. However, Cote and Wolfe's (2014) study on the barriers to installing permeable surfaces in single-family residential units as well as the characteristics and incentives (i.e. motives) associated with early adopters has attempted to address this knowledge gap. Thus, as outlined in the study's first research objective, this particular study has, to some extent, attempted to expand the scope of Cote and Wolfe's (2014) study by identifying and examining the *physical and contextual* factors, *situational and behavioural* factors, as well as the *socio-demographic* factors that may have an influence (whether as barriers or incentives) on the household uptake of not only PP but also RWH and GWR.

Furthermore, South African-based literature, particularly case studies, on the household uptake of selected WSUD measures and WSUD in general – is limited. Therefore, by applying this particular empirical study to two South African metropolitan areas, i.e. the Cities of Cape Town and Tshwane, this study can contribute towards the existing body of knowledge on the urban household uptake of selected WSUD measures in South Africa.

The subsequent section discusses the key arguments featured in existing literature on household-related municipal water demand-side management (DSM) instruments, which include 'assistance to implement WSUD measures. Therefore, because the implementation of WSUD measures constitutes a type of municipal water DSM instrument, it was deemed important to examine urban household preferences for WSUD in relation to more conventional municipal water DSM instruments; hence the third research objective.

2.4 Household Demand-side Management Instruments

Existing literature on household-relevant municipal water DSM instruments commonly defines the term, i.e. DSM instruments, identify and define the various types and discuss factors that influence the effectiveness of each of the numerous DSM instruments (Cameron & Wright, 1988; Terpstra, 1999; Renwick & Green, 2000; Gilg & Barr, 2006; Inman & Jeffrey, 2006; Vernon & Tiwari, 2009; Gilbertson et al., 2011; Makki et al., 2011; Willis et al., 2011; Fielding et al., 2012; Attari, 2014; Dascher et al., 2014; Coelho et al., 2016; Ahammed, 2017; Brick et al., 2017). The key contentions that emerged during the process of reviewing existing literature, i.e. as discussed as part of each of the above-identified themes or areas of scholarly research, are outlined below.

2.4.1 Demand-side Management Instruments: Definition and Types of Instruments

DSM instruments, or rather municipal water DSM instruments, refer to instruments developed to reduce the amount of municipal water that consumers use and demand (Wegelin & Jacobs, 2012; Dascher et al., 2014). For the purpose of this study, municipal water DSM instruments refer to instruments that are developed and taken up to reduce the amount of potable municipal water that is used and demanded by urban households.

Regarding the types of municipal water DMS instruments, the instruments consist of both price (i.e. related to the price of water) and non-price instruments (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014). As such, in addition to education campaigns on water, water conservation, and particularly water conservation measures – water use restrictions; as well as subsidies for the installation of water conservation technologies and the uptake of WSUD measures, i.e. at household level, commonly feature as types of non-price DSM instruments; while rationing and block rates feature as price DSM instruments for households in the existing body of knowledge (Renwick & Green, 2000; Vernon & Tiwari, 2009; Fielding et al., 2012; Dascher et al., 2014). Descriptions of each of the types are provided below.

Education campaigns on water and water conservation commonly feature among the various types of municipal water DSM instruments for urban households and households in general, i.e. in the existing body of knowledge (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014). The rationale behind this DSM tool is to build community awareness on water issues by alerting households about shortages and informing them about available strategies to curb demand. This instrument aims to encourage the adoption of pro-environmental behaviour (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014).

Water use restrictions represent another type of municipal water DSM instrument for households. As outlined earlier, these restrictions limit which (and when) certain types of municipal water use activities may occur (Renwick & Green, 2000). Typical examples of water use restrictions include bans on lawn or garden irrigation, bans on filling up swimming pools, prohibitions on using water to wash or clean up paved outdoor surfaces, as well as restrictions on the use of hosepipes for outdoor water use activities such as washing a car, or cars as well as outdoor surfaces such as paved surfaces and roofs (Renwick & Green, 2000; Pinto & Maheshwari, 2010; Fielding et al., 2012; Dascher et al., 2014).

The provision of subsidies by local authorities or other water service providers to households, to encourage the adoption and consequent use of various water-efficient technologies as well as the uptake of various WSUD measures, constitutes another type of household-related municipal water DSM instrument (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014). Subsidized water-efficient technologies typically range from dual-flush toilet(s), rebate programs and retrofit kits – which include low-flow showerheads, tank displacement devices, and dye tablets for leak detection – to eco-friendly home appliances, such as washing and dishwashing machines (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014). WSUD measures, as noted by Vernon and Tiwari (2009), also form part of municipal water DSM instruments. As outlined in Chapter 1, such measures encompass the use of both water conservation technologies and systems such as GWR systems, RWH tanks, as well as environmentally sensitive design measures such as PP (or porous surfaces), i.e. amongst others (Renwick & Green, 2000; Vernon & Tiwari, 2009; Fielding et al., 2012; Dascher et al., 2014; Ahammed, 2017).

Regarding price, i.e., price-related, DSM instruments, rationing is featured amongst the relevant municipal water DSM instruments in the existing literature (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014). Rationing usually involves allocating a fixed quantity of water to individual households, coupled with penalties imposed when the pertinent households' water consumption exceeds the allotment of water. Moreover, *increased block rates* constitute another example of a price DSM instrument that commonly features in the existing body of knowledge (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014). This instrument involves increases in water price based on the metered use, usually resulting in high(er) water rates per increase in water usage (Renwick & Green, 2000; Fielding et al., 2012; Dascher et al., 2014).

The factors Influencing the effectiveness of various municipal water DSM instruments, are discussed in the proceeding subsection.

2.4.2 Factors Influencing the Effectiveness of Demand-side Management Instruments

The effectiveness of municipal water DSM instruments and the factors that influence their respective effectiveness features prominently as a subject in the published literature on household municipal water DSM instruments (Inman & Jeffrey, 2006; Makki et al., 2011; Willis et al., 2011). The contexts under which the various DSM instruments are implemented, as well as combinations of instruments that are often implemented simultaneously, or in some cases successively, feature as key factors that have been found to influence the effectiveness of various municipal water DSM instruments (Renwick & Green, 2000; Inman & Jeffrey, 2006; Dascher et al., 2014).

For instance, Renwick and Green (2000), Inman and Jeffrey (2006), as well as Dascher et al. (2014) highlight the importance of understanding and providing data about the combination of instruments that are implemented, if applicable, as well as the contexts within which the various instruments are implemented; and argue that different combinations of instruments and contexts produce varying degrees of *effectiveness* for each DSM instrument (Cameron & Wright, 1988; Terpstra, 1999; Gilg & Barr, 2006; Inman & Jeffrey, 2006; Olmstead & Starvins, 2009; Makki et al., 2011; Willis et al., 2011; Renwick & Green, 2000; Gilbertson et al., 2011; Attari, 2014; Dascher et al., 2014; Coelho et al., 2016; Brick et al., 2017).

For example, in their study, which aimed to assess the relative performance of various municipal water DSM instruments, i.e. in terms of reducing water demand – Renwick and Green (2000) found that the demand for water by households was responsive to changes in the price of water (i.e. price responsive). Moreover, they discovered that relevant *price responsiveness* varied seasonally, as demand for household water was 25% more responsive in the summer months (Renwick & Green, 2000), thus indicating the relative effectiveness of price DSM instruments in the months of summer.

Inman and Jeffrey (2006), on the other hand, found households' outdoor use of water to be more responsive to both price DSM instruments and water use restrictions, as opposed to indoor water use; indicating the effectiveness of imposing household water use restrictions particularly on outdoor water use activities (Inman & Jeffrey, 2006). Similarly, in their survey study of water consumers in the USA (i.e. United States of America) state of Texas, Dascher et al. (2014) reached the following conclusion:

> "…the results of this study lead to the suggestion that policy makers focus upon *water restrictions* and *educational campaigns* as part of their DSM of water resources, as opposed to providing incentives for water conservation technologies." (Dascher et al., 2014, p. 467, ***emphasis mine***)

The above thus indicates how implementing certain combinations of various municipal water DSM instruments can yield optimal results in terms of achieving efficacy when it comes to saving water. Literature on household perceptions of municipal water DSM instruments is discussed in the subsequent subsection.

2.4.3 Household Perceptions of Demand-side Management Instruments

Literature on households' perceptions of municipal water DSM instruments, as well as perceptions about the effectiveness thereof, is quite limited; with significant literature on the subject of *household water use and perceptions* focusing on households' and water users' perceptions about the consumption quality of bottled versus potable (tap) water, as well as the perceived effectiveness of various price-related approaches to water conservation (Doria et al., 2009; Onufrak et al., 2014; Lu et al., 2019). However, Attari's (2014) study which explored domestic water users' perceptions about the type of water conservation strategies they deemed effective in reducing their relevant household water consumption, came close (Attari, 2014).

According to Attari (2014), when asked about the most effective strategy to implement to conserve water in their relevant households, most respondents identified behavioural nudges, which refer to mundane behavioural adjustments to curtail water use, such as taking shorter showers and turning off the tap (i.e.running water) while brushing teeth, i.e. as opposed to the uptake or use of water-efficient technologies – which is often a largely recommended type of municipal water DSM instrument (Vernon & Tiwari, 2009; Attari, 2014; Ahammed, 2017; Brick et al., 2017). This finding might be attributed to the relatively limited amount of effort required to adopt behavioural nudges, i.e. when compared to installing or retrofitting water efficient technologies.

Charalambous et al.'s (2018) study, which aimed to determine whether or not citizens' perception(s) of the effectiveness of RWH systems, permeable pavements (or PP) and green roofs, affected their willingness to implement them – constitutes another study which focuses on households' perceptions of WSUD measures. As noted earlier, the provision of subsidies, or any other form of assistance to implement WSUD measures at household level – is also a type of municipal water DSM instrument (Vernon & Tiwari, 2009; Ahammed, 2017; Charalambous et al., 2018). However, for their particular study, Charalambous et al. (2018) refer to the relevant measures, i.e. RWH systems, permeable pavements and green roofs, as household level flood protection measures as opposed to either WSUD measures or types of municipal water DSM instruments (Charalambous et al., 2018). Moreover, in that regard, most respondents from Charalambous et al.'s (2018) study perceived RWH systems and permeable pavements as effective when it comes to reducing flooding in urban areas, while green roofs were perceived as least effective (Charalambous et al., 2018).

2.4.4 Summary: Household Demand-side Management Instruments

As noted earlier, published literature on household-related municipal water DSM instruments commonly defines and describes what is meant by the term *DSM instruments* and identifies the various types – each of which can be classified as either price or non-price DSM instruments. Moreover, literature on the effectiveness of various municipal water DSM instruments and the factors that influence their effectiveness, constitutes a key area of research for studies on household municipal water DSM instruments. Regarding literature on households' perceptions of DSM instruments, both Attari's (2014) and Charalambous et al.'s (2018) studies have attempted to explore households' or water users' perceptions about the effectiveness of various municipal water DSM instruments. However, the latter study referred to RWH and PP as household level flood protection measures instead of WSUD measures. Furthermore, and as noted earlier, from the list of published studies that were reviewed for this particular review, only Vernon and Tiwari (2009) acknowledge the link between WSUD and municipal water DSM instruments by referring to DSM instruments as "an element of policy initiatives in the demand management of water" (Vernon & Tiwari, 2009; Ahammed, 2017, p. 270).

As such, this particular study endeavoured to address this particular knowledge gap by acknowledging and identifying RWH, PP and GWR as WSUD measures and a type of municipal water DSM instrument, i.e. in addition to exploring households' perceptions of the effectiveness of (and their inherent preferences for) various municipal water DSM instruments – which are inclusive of the implementation of, as well as the provision of assistance to implement WSUD measures.

2.5 Conclusion

The limitations (i.e. in the form of knowledge and research gaps) of the literature on (*i*) the household uptake of selected WSUD measures, including RWH, PP and GWR, as well as literature on (*ii*) the factors influencing the household uptake of selected WSUD measures, and (*iii*) household level water DSM instruments – are outlined in this section of the literature review (Chapter 2). Furthermore, this chapter is concluded by a brief discussion of the various research approaches that the reviewed studies have taken.

2.5.1 Knowledge Gaps

As informed by the conducted review, the following research and knowledge gaps were identified:

<u>For the first (1st) objective of the literature review, the following gaps were identified:</u>

Selected WSUD measures, particularly RWH and GWR, are predominantly presented and discussed as alternative, supplementary or household water sources. At the same time, RWH and PP are commonly identified as either household level flood protection measures or NWRM (i.e. natural water retention measures). Furthermore, literature on the temporal, i.e. past, present and future, uptake of selected WSUD measures ranges between limited to non-existent. However, results from such studies are typically dependent on the relevant contexts of application. Thus, in addition to acknowledging RWH, PP, and GWR as WSUD measures, the temporal aspect of the research is indicative of the study's niche.

For the second (2nd) objective of the literature review, the following research and knowledge gaps were identified:

Literature on the factors influencing the household uptake of PP is limited. However, Cote and Wolfe's (2014) study that outlines the barriers to installing permeable surfaces in single-family residential properties, as well as the characteristics and motives associated with early installers of PP, has attempted to address this knowledge gap (Cote & Wolfe, 2014). As such, by identifying and examining the *physical and contextual* factors, *situational and behavioural* factors, as well as the *socio-demographic* factors that may have an influence (whether as barriers or incentives) on the household uptake of PP as well as RWH and GWR – this particular study has, to some extent, expanded the scope of Cote and Wolfe's (2014) study.

Furthermore, published African case studies, on the household uptake of selected WSUD measures and WSUD in general – are limited. Therefore, by applying this particular empirical study to two South African metropolitan areas, i.e. the Cities of Cape Town and Tshwane – this study aspires and intends to contribute towards the African-based existing body of knowledge on the urban household uptake of selected WSUD measures.

For the third (3rd) objective of the literature review, the following knowledge gap was identified:

Published studies that identify WSUD measures as a type of water DSM instrument are limited, with only a few scholars such as Vernon and Tiwari (2009) and Ahammed (2017) acknowledging the role of WSUD measures in municipal water DSM policy (Vernon & Tiwari, 2009; Ahammed, 2017). As such, this study aspired to address this knowledge gap by identifying the provision of 'assistance to implement WSUD measures' among various other municipal water DSM instruments and by further examining domestic water users' preferences for selected WSUD measures as effective municipal water DSM instruments.

2.5.2 Approaches to Research

Research into the household uptake of selected WSUD measures, particularly research into the factors that influence urban households' uptake of selected measures and research on household-related municipal water DSM instruments, has taken several approaches. Quantitative research, in the form of self-administered surveys, as well as quantitative analyses, emerged as the most common approach to research for all three topics (Cameron & Wright, 1988; Renwick & Green, 2000; Gilg & Barr, 2006; Doria et al., 2009; Olmstead & Starvins, 2009; Noiseux & Hostetler, 2010; Parsons et al., 2010; Pinto & Maheshwari, 2010; (Makki et al., 2011; Willis et al., 2011; Coelho et al., 2016; Fielding et al., 2012; Bjornlund et al., 2013; Ward et al., 2013; Attari, 2014; Cote & Wolfe, 2014; Dascher et al., 2014; Mukheibir et al., 2014; Onufrak et al., 2014; Baiyegunhi, 2015; Chowdhury et al., 2015; Hayden et al., 2015; Zou et al., 2015; Brick et al., 2017; Fisher-Jeffes et al., 2017; Nel et al., 2017; Schirmer & Dyer, 2018; Amodeo & Francis, 2019; Lu et al., 2019). This was followed by qualitative approaches, which were facilitated through in-depth interviews, as well as field evaluations or observations (Booth & Leavitt, 1999; Terpstra, 1999; Inman & Jeffrey, 2006; Maimon et al., 2010; Dzidic & Green, 2012; Mayer et al., 2012; Brown et al., 2016; Ahammed, 2017; O'Donnell et al., 2020). Fewer studies applied a mixed-method approach, which entailed surveys and interviews or focus group discussions (FGD) (Brown & Davis, 2007; Domenech & Sauri, 2011; Fewkes, 2012; Charalambous, et al., 2018; Mason, et al., 2018). These, therefore, provide insight into the most suitable approach for this particular study.

CHAPTER 3: METHODOLOGY

The purpose of this chapter is to describe the process of how this study was conducted. As such, the chapter outlines the relevant research design, the various considerations that lead to selecting the research design, and the theoretical assumptions behind them. This is followed by a discussion on the research methods applied to this study, including sampling, data collection, and data analysis processes, while a discussion on the limitations of the methodology concludes the chapter.

3.1 Research Design

As noted in Chapter 1, this study emanates from a larger Council for Scientific and Industrial Research (CSIR) and University of Pretoria (UP) collaborative research project on urban household water use behaviours. The project's survey instrument, which included a set of questions on Water Sensitive Urban Design (WSUD), was applied to this particular study. As a result, this study's research design was informed by the broader research project, and the relevant survey instrument, i.e. questionnaire – which is attached herein as APPENDIX 1. Therefore, this particular study follows an inductive approach, as informed by the applied survey instrument, which "involves the search for a pattern [or patterns] from observation[s] and the development of explanations – i.e. theories – for those patterns through series of hypotheses" (Bernard, 2011, p.7). In particular, an inductive approach aims to generate meanings from collected data sets in order to identify patterns and relationships to build a theory (Bernard, 2011; Saunders, et al., 2012). The methodological aspects related to the study's research design are discussed below.

3.1.1 Research Design Considerations

Du Toit and Mouton (2013) define the term *research design* as "a logical plan" (Du Toit & Mouton, 2013, p. 4) that involves strategic decisions [i.e. decisions about various design considerations across a variety social research dimensions] and aims to maximise the validity of research findings (Du Toit, 2010; Du Toit & Mouton, 2013). Moreover, the dimensions of social research are described as:

"decision points for a researcher when moving from a broad topic to a focused research question to the design of a specific study" (Du Toit, 2010, p. 26)

Several social research dimensions have been identified, namely sociological, teleological, ontological, epistemological and methodological dimensions (Du Toit, 2010). However, bearing in mind that this is a methodology chapter, particular focus was placed on the latter dimension, i.e. the methodological dimension of social research, which involves details on how to conduct social research. Important considerations for research design in the methodological dimension include (1) the use and audience of the research, (2) the methodological paradigm, (3) the purpose of the research, (4) the methodological research approach, as well as (5) the use of time in research or the time dimension. These considerations should ultimately lead to selecting an appropriate (6) research design (Du Toit, 2010; Du Toit & Mouton, 2013; Neuman, 2007; Neuman, 2014).

Therefore, considering the methodological dimension of social research, the considerations for this study's research design and the applicable research design are outlined below in Table 5.

Table 5: Design considerations and Research Design

Design Considerations	
Use and audience of Research	Mostly Basic Research, with aspects of Applied Research
Methodological Paradigm	Post-positivism and Pragmatism
Research Purpose	Explorative, Descriptive and Comparative
Methodological Approach	Quantitative
Time Dimension	Cross-sectional
Research Design	Survey

As indicated in Table 5, the first consideration is that of *use and audience of research*. This refers to one's orientation, particularly a researcher's orientation, towards the intended use of the research and the target audience of the research. The orientations towards research include *basic research*, which refers to research that is undertaken to "advance fundamental knowledge about the [e.g. social] world" (Neuman, 2014, p. 26), i.e. in terms of how the world works, as well as to develop or test theories that focus on the question "why?". *Applied research*, which is primarily "designed to offer practical solutions to concrete problems (Neuman, 2014, p. 27), constitutes another orientation towards research. As such, because this particular study is primarily designed to advance" fundamental knowledge in the areas of urban household water use practices, and more specifically, the household uptake of WSUD measures, the study was identified as a form of predominantly basic research. Moreover, by outlining possible directions for further research and formulating indicative policy and planning recommendations for WSUD in a South African context, the study also demonstrates characteristics of applied research (Neuman, 2014).

The second research design consideration is that of a *methodological paradigm*. A paradigm can be defined as an organizing structure, framework, or a basic set of believes that represent a researcher's orientation, worldview or philosophical assumptions concerning theory and research (Armitage, 2007; Du Toit & Mouton, 2013; Feilzer, 2010; Neuman, 2014; Kaushik & Walsh, 2019; SAGE Publications, 2020). Feilzer (2010) as well as Kaushik and Walsh (2019) provide the following definitions for methodological paradigm:

> " A paradigm could be regarded as an accepted model or pattern. . .as an organising structure, a deeper philosophical position relating to the nature of social phenomena and social structures" (Feilzer, 2010, p. 7)

> "A paradigm is used to refer to the philosophical assumptions or to the basic set of beliefs that guide the actions and define the worldview of the researcher" (Kaushik & Walsh, 2019, p. 2)

As such, *post-positivism* and *pragmatism*, were identified as the study's methodological paradigms. With a few exceptions, there are two common orientations, or philosophical assumptions, toward ontology (which focuses on what exists, or rather the fundamental nature of reality) and epistemology (which focuses on the production and appearance of scientific knowledge) (Neuman, 2014). The two opposing positions are those of 'realists' and 'nomalists' within ontology and epistemology. Thus, concerning ontology, "realists assume that the real world exists independently of humans and their interpretations of it" (Neuman, 2014, p. 94). In contrast, nomalists assume that "human experience of the real world is always occurring through a lens or scheme of interpretations and inner subjectivity and that subjective-cultural beliefs influence what people see and how they experience reality" (Neuman, 2014, p.94). In terms of epistemology, realists produce knowledge and study reality by making careful observations of it; they believe an empirical world exists apart from people's inner thoughts and perceptions (Neuman, 2014). On the other hand, for nomalists to produce scientific knowledge, they must "inductively observe, interpret, and reflect on what other people are saying and doing in specific contexts while simultaneously reflecting on their own experiences and interpretations" (Neuman, 2014, p.94).

These positions relating to ontology and epistemology thus inform the various methodological paradigms that exist today, with the common ones being the post-positivist social science paradigm, or post-positivism (which most realists adopt) and the interpretative social science (which most nomalists adopt). Moreover, it is important to note that paradigms also inform the research approaches and techniques that researchers select. However, and as noted earlier, both pragmatism and post-positivism were identified as the relevant paradigms for this particular study. According to Kaushik and Walsh (2019), pragmatism represents the following:

> "a paradigm that claims to bridge the gap between the scientific method and structuralist orientation of older approaches and the naturalistic methods and freewheeling orientation of newer approaches" (Kaushik & Walsh, 2019, p. 2)

Therefore, as a paradigm, pragmatism attempts to accommodate the opposing positions in one study. Pragmatism also refers to a worldview that focuses on 'what works,' i.e. as opposed to what might be considered as absolutely true or real in terms of epistemology and ontology (SAGE Publications, 2020). Hence, by exploring people's perceptions of effective demand-side management (DSM) instruments (i.e. the third research objective), the nomalist position is upheld. In contrast, the realist's orientation towards research is appropriately encapsulated by this study's second objective, aiming to examine the association between the household uptake of Water Sensitive Urban Design (WSUD) measures and the possible predictors thereof. Neuman (2014) argues that the discovery of causal laws – which explore cause and effect relationships– constitutes the primary objective of the post-positivist paradigm, as commonly adopted by realists (Neuman, 2014). Moreover, "post-positivist researchers prefer precise quantitative data and often use experiments, *surveys* and statistics" (Neuman, 2014, p. 97, ***emphasis mine***). Furthermore, since the study made use of a questionnaire (APPENDIX 1) with the aim of determining certain social patterns that may be assumed to be more-or-less universal to society, or at least the South African society – post-positivism was, as such, identified as a relevant paradigm for this particular study.

The third design consideration is that of *research purpose*. As outlined in Table 5 and the research aim in Chapter 1, Section 1.5.2., the purpose of this study is to *explore* and *describe*, while *comparing* results from two case areas throughout the study. Exploratory research typically examines novel research areas intending to formulate questions to be addressed by future studies. In comparison, descriptive research is concerned with producing detailed pictures of specific research subjects, i.e. specific situations, relationships or social settings (Neuman, 2007; Du Toit & Mouton, 2013; Neuman, 2014).

Concerning the fourth design consideration, which focuses on the study's methodological approach to research, a quantitative approach to research was identified. A methodological approach involves strategies concerned with the use of different types of data. In this case, the type of data that was gathered and analysed for the study was primarily quantitative, and as a result, a quantitative research approach was identified (Du Toit, 2010; Neuman, 2014).

Quantitative research involves collecting and analysing data in numerical form, which is how this particular study's findings were produced. Furthermore, a quantitative approach is usually associated with more structured research designs and is more likely to use numerical data while objectifying reality. Quantitative studies are also more likely to have explanatory and descriptive research purposes (Jupp, 2006; Neuman, 2007; Du Toit & Mouton, 2013; Neuman, 2014).

These considerations ultimately led to identifying a research design for this particular study, which is a survey. The reasoning behind surveys is that they make generalisations about populations that are studied – which is what this particular study intended to do. Moreover, because this study's survey instrument was designed to examine the water use behaviours of urban households through a single point in time – and in an attempt to acknowledge this *time* dimension of social research – the design of the study is best described as a *cross-sectional* survey (Neuman, 2007; Du Toit & Mouton, 2013; Neuman, 2014).

Details surrounding the study's questionnaire design and research methods are discussed below.

3.1.2 Questionnaire Design and Research Ethics

In line with the selected research design, a survey instrument in the form of a questionnaire (APPENDIX 1) focusing on urban household water use behaviour and municipal water DSM instruments was designed by a research team from the CSIR's *Smart Places* cluster; while the project team members from UP added items on WSUD to the questionnaire. Moreover, given the study's exploratory aim, several factors that were hypothesized to influence household water use behaviour and the uptake of WSUD measures were also included in the questionnaire.

Ethical clearance was obtained from the Research Ethics Committees of both the CSIR and the Faculty of Engineering, Built Environment and Information Technology (EBIT) at the UP. The ethical clearance included several requirements such as informed consent and voluntary participation from respondents, for responses to remain anonymous, and for data to be managed according to the respective institutional policies.

For instance, to protect [or ensure] survey respondents' right to privacy – all student researchers [who also assumed roles as fieldworkers] – were obligated to sign a student researcher declaration. As illustrated in the provided copy – attached herein as APPENDIX 3 – fieldworkers were, amongst other things, expected to *"treat all responses of respondents confidentially. . ."* Furthermore, items four and six of the survey participation consent form (APPENDIX 2) which was handed to respondents before each survey interview – outlines the processes that were put in place to maintain respondents' confidentiality.

To maintain the requirement for the voluntary participation of respondents, and as outlined in item eight of the consent form (APPENDIX 2), as well as item *b.* of the student researcher declaration form (APPENDIX 3) – respondents were informed of their right to withdraw from the survey interview anytime they felt like doing so. Similarly, to demonstrate that respondents participated in the survey interviews voluntarily – the respondents themselves were required to provide consent by filling out the form in question, a copy of which is attached herein as APPENDIX 2. As also illustrated on the form (APPENDIX 2), respondents were provided with an option of providing either written, or verbal consent to participate in the survey interviews.

3.2 Research Methods

3.2.1 Fieldworker Training

Survey fieldworkers consisted of several project team members from the CSIR's *Smart Places* cluster and research students from UP's Town and Regional Planning and Psychology departments. Both the CSIR and UP fieldworkers attended rigorous fieldwork training, during which the study and questionnaire were explained, and mock interviews were conducted. The fieldwork and safety protocols were established during the training. Moreover, in addition to meeting the ethical requirements, each research student signed an indemnity form to abide by the fieldwork and safety protocols (APPENDIX 4).

3.2.2 Sampling and Sample Size

The CSIR team, in liaison with the municipal officials and representatives of the Cities of Cape Town and Tshwane, compiled a sample of purposefully selected neighbourhoods in both the Cities of Cape Town and Tshwane. The sampled neighbourhoods consisted of a wide range of settlement types, including inner cities, suburban areas, satellite towns, townships and informal settlements. The same applied to housing types, ranging from free-standing houses, single-storey duplexes, double-storey flats and multi-storey flats to duets and informal dwellings.

However, only data from former 'black' townships as well as satellite towns and suburban areas (or suburbs) were analysed and reported on for this particular study. Moreover, housing types were limited to free-standing houses and single-storey duplexes. These delimitations were put in place as it makes sense to only look at housing types that are suitable for taking up WSUD measures, which in this case, include free-standing houses and single-storey duplexes. For instance, sufficient outdoor or rooftop space is a prerequisite for installing a rainwater harvesting (RWH) system, or rain, barrel; and the availability of adequate outdoor surface area is essential for installing permeable paving (PP). Therefore, considering the above, it is argued that multi-family dwellings – which are often associated with shared spaces such as rooftops and outdoor surface areas – may obstruct individual households from taking up selected WSUD measures.

Furthermore, although some informal dwelling units have access to exclusive outdoor surface areas, these areas are often limited in size; plus the lack of access to conventional water and sanitation services, which characterises a majority of the households found in informal settlements, does not maintain the definition of WSUD completely – which, as outlined in Chapter 1, involves the integration of urban development with the management of a comprehensive urban water cycle, as made up of wastewater management, potable water management and stormwater management (Armitage et al., 2014). Moreover, informal settlements were also excluded to 'control' for stark differences (i.e. in terms of characteristics) between formal and informal settlements. As such, only formal settlements were considered to avoid a conflation of very different responses.

Additionally, as highlighted by Garcia et al. (2015), several researchers have identified that average water consumption in detached houses is consistently larger than in higher density residential buildings; and that this is a result of the presence of water-consuming recreational activities such as gardening and swimming, i.e. the filling up of swimming pools (Garcia et al., 2015) – thus providing an incentive for the uptake of the selected WSUD measures in similar households.

The definitions for both the settlement and housing types that were sampled for this particular study are provided below in Table 6.

Table 6: Definitions for sampled housing and settlement types

Housing Type	**Definition**
Free-standing house	A housing structure or building on its own block of land; that does not rely on another structure for support, i.e. with no shared walls. Common features include a kitchen, bathroom, living area(s), bedroom(s), garden and/or outdoor surface area, etc.) (WebFinance Inc., 2020).
Single-storey duplex	"A single-storey housing structure that is divided into two residences. Each residence, or household, has its own driveway, own garden, and all the features that you [would] expect from a free-standing house (e.g. kitchen, bathroom, living areas, bedrooms, etc.). A duplex just has a single shared wall that separates the two homes from each other" (WebFinance Inc., 2020, p. online source).

Table 6: Definitions for sampled housing and settlement types

Settlement Type	Definition
Suburban area	A residential area around a major city A suburb, or suburban area, is a predominantly residential area that is usually "located at the edge of an urban city and contained either just within or just outside of the city boundaries. A suburban area is often dependent upon the nearby city for employment opportunities and other socio-economic activities" (WebFinance Inc., 2020, p. online source).
Satellite town	A smaller "self-contained" city, or town, that is located either near, or within, a large(r) metropolitan area. Although satellite towns are usually counted as part of a larger metropolitan area, they often have their own business districts and urban cores – which are typically self-sufficient and independent from metropolitan areas. Therefore, a satellite town can be defined as an area that forms part of an urban metro but still exists independently of the larger urban core (Places Journal, 2020).
Former black township(s)	Refers to racially segregated areas that were previously designated for people who were classified as Africans, Coloureds or Indians, i.e. under the apartheid regime. Usually situated on the urban edge, these areas were relatively underdeveloped and divorced from the mainstream economy. These areas experienced racial segregation and socio-economic exclusion. They also had marginal provision of essential services (Sibiya & Ozumba, 2010).

Therefore, given the focus on the household uptake of WSUD measures, as well as the delimitations imposed on the study, results are based on a subsample of 250 households (N=250); with 125 households located in each of the case areas, i.e. the City of Cape Town (N=125) and the City of Tshwane (N=125). This was also done to present an equal sample size between the two Cities for statistical purposes. Table 7 below outlines the number of households sampled for this particular study, i.e. by municipality as well as settlement and dwelling type.

Table 7: Sample of households by the municipality, settlement type, and dwelling type

		City of Cape Town	City of Tshwane	Total
		Count	**Count**	**Count**
Suburb/satellite town	Free-standing house	79	88	167
	Single-storey duplex	11	2	13
	Total	**90**	**90**	**180**
Former black township	Free-standing house	32	35	67
	Single-storey duplex	3	0	3
	Total	**35**	**35**	**70**
Total	Free-standing house	111	123	234
	Single-storey duplex	14	2	16
	Total	**125**	**125**	**250**

As illustrated in Table 7, in each municipality, most of the households sampled for this particular study are located in suburbs and satellite towns (N=90), with minimum households sampled from former black townships (N=35). Regarding housing types, a majority of respondents resided in free-standing houses (N=234), while a considerable minimum (N=16) resided in single-storey duplexes.

For the City of Cape Town, the imposed delimitations resulted in the sampling of households from three former black townships, namely Atlantis, Gugulethu and Rylands; as well as 17 suburbs and satellite towns, namely Durbanville, Wynberg, Plattekloof, Gordons Bay, Muizenberg, Camps Bay, Brackenfell, Kraaifontein, Kalk Bay, Gatesville, Seapoint, Strand, Ridgeway, Oakdale, Bellville, Goodwood and Rylands. The latter settlement has characteristics of both a suburb and a former black township and could be identified as a mixed area. Tables 8 illustrates the number of sampled households in the City of Cape Town by settlement and settlement type.

Table 8: Number of sampled households in the City of Cape Town by settlement and settlement type

Settlement	Settlement Type		
	Suburb/satellite town	Former black township	Total
	Count	Count	Count
Atlantis	*	17	17
Durbanville	14	*	14
Wynberg	13	*	13
Gugulethu	*	12	12
Plattekloof	12	*	12
Rylands	5	6	11
Gordons Bay	9	*	9
Muizenberg	7	*	7
Camps Bay	7	*	7
Brackenfell	7	*	7
Kraaifontein	4	*	4
Kalk Bay	2	*	2
Gatesville	2	*	2
Seapoint	2	*	2
Strand	2	*	2
Ridgeway	1	*	1
Oakdale	1	*	1
Bellville	1	*	1
Goodwood	1	*	1
Total	**90**	**35**	**125**

Concerning the City of Tshwane, households were sampled from only one former black township, namely Mamelodi, and the rest were sampled from 18 suburbs and satellite towns, including Arcadia, Queenswood, Villeria, Moreleta Park, Theresa Park, Loftus, Lydiana, Clydersdale, Pierre van Ryneveld, Murrayfield, Lynwood, Garsfontein, Riviera, Colbyn, Irene, Orchards, Rayton and Kilner Park. Table 9 outlines the various settlements identified for this particular study, i.e. in the City of Tshwane, as well as the number of sampled households in each of the settlements.

Table 9: Number of sampled households in the City of Tshwane by settlement and settlement type

Settlement	Settlement Type		
	Suburb/satellite town	Former black township	Total
	Count	Count	Count
Mamelodi	*	35	35
Colbyn	24	*	24
Irene	10	8	10
Orchards	8	*	8
Rayton	7	*	7
Kilner Park	7	*	7
Arcadia	5	*	5
Queenswood	5	*	5
Villeria	5	*	5
Moreleta Park	4	*	4
Theresa Park	3	*	3
Loftus	2	*	2
Lydiana	2	*	2
Clydersdale	2	*	2
Pierre van Ryneveld	2	*	2
Murrayfield	1	*	1
Lynwood	1	*	1
Garsfontein	1	*	1
Riviera	1	*	1
Total	**90**	**35**	**125**

Moreover, in addition to minimising the number of sampled households in terms of settlement and housing types, several other sample requirements were identified to further define the study's target population. These are outlined in the subsequent subsection.

3.2.3. Data Collection

3.2.3.1. Fieldwork

Fieldworkers visited selected neighbourhoods in teams of two and followed a convenient door-to-door sample of households in free-standing houses and single-storey duplexes across the sampled neighbourhoods in both the Cities of Cape Town and Tshwane. The surveys were conducted between August 2018 and July 2019 Each fieldworker was instructed to secure any willing and 'readily available' urban householder from the sampled neighbourhoods situated across the relevant case areas. However, upon securing a householder, fieldworkers were instructed to request for the head of the household, and in instances whereby the household head was unavailable or unable to participate in the survey interview – a household member, at least 18 years of age or older, would then assume the role of being the survey respondent.

Moreover, to qualify as a survey respondent for this particular study, one had to meet the following criteria, i.e. at the time the survey interviews were conducted:

- be an urban householder;
- be either 18 years of age or older;
- live in either a free-standing house or a single-storey duplex;
- situated in either a suburban area, satellite town or a former black township;
- located in either the City of Cape Town or the City of Tshwane.

Furthermore, respondents had to rely on municipal, borehole, or other (e.g. bottled) water sources for essential household activities such as drinking and preparing food (e.g. cooking).

3.2.3.2. Data Capturing and Cleaning

A debriefing workshop was facilitated at the end of the fieldwork, during which students shared lessons learnt and received training to capture the data in Microsoft Excel. Following cross-checks by the UP team, data were exported, cleaned and analysed using the Statistical Package for the Social Sciences (SPSS), Version 26.

3.2.4. Data Analysis

3.2.4.1. Objective 1

To meet the first research objective, survey responses from question 26 of the questionnaire (APPENDIX 1) – in which respondents were asked to indicate whether they used each of the selected WSUD measures ‘this time last year,’ ‘now’, and whether they thought they would use the measures ‘this time next year’ – were analysed. A frequency and percentage distribution table was compiled with Chi-square and Fisher’s exact tests. To address the comparative aspect of this study, the Chi-square and Fisher’s exact tests were conducted to test for significant differences between the City of Cape Town and the City of Tshwane (df = 1). Chi-square tests are based on the likelihood ratio considering small samples, whereas a Fisher’s exact test was used where expected counts < 5. Statistical significance in this study was calculated at the 95% confidence level (alpha = 0.05).

3.2.4.2. Objective 2

Regarding the second research objective, findings from the literature review (Chapter 2) were used to inform the design of an analytical framework. As outlined in the literature review (Chapter 2), six sets of factors that have been found to influence the uptake of selected WSUD measures by urban households, which are also referred to as possible predictors, were identified. As illustrated in Figure 6(a), and as outlined in the literature review (Chapter 2), these include factors related to *awareness* and *attitudes*, *physical and contextual* factors, *behavioural and situational* factors, *socio-demographic* factors, as well as *institutional arrangements*. Individual factors from each of the identified sets were evaluated against the predesigned questionnaire (APPENDIX 1) to translate these sets of factors into an analytical framework and to determine the extent to which each factor featured as a measure in the subject questionnaire. The factors that were then found to feature in the survey instrument were adapted to the questionnaire itself and this particular study. The outcomes of this exercise are outlined in Table 10, as illustrated below.

Table 10: Factors influencing the household uptake of Water Sensitive Urban Design measures as featured in the literature review and survey questionnaire

Possible predictors, as identified in the literature review	(Possible predictors) Independent variables as featured in the subject questionnaire and subject study
Awareness	
Environmental Awareness	Not measured as part of this study. Not measured by the applied questionnaire (Reference: APPENDIX 1).
Awareness of selected WSUD measures, i.e. GWR, RWH and PP	Not measured as part of this study. Not measured by the applied questionnaire (Reference: APPENDIX 1).
Attitudes	
Attitudes towards selected WSUD measures, i.e. GWR, RWH and PP	Not measured as part of this study. The items outlined in the applied questionnaire's New Environmental Paradigm (NEP) scale (Reference: APPENDIX 1; Question 16) – which measures environmental attitudes – did not include WSUD measures amongst other items on the scale, nor did it outline domestic water users' possible attitudes towards them.
Physical and Contextual factors	
Access to Municipal or Centralised [Potable] Water Supply	The main source of water for drinking and preparing food (Reference: APPENDIX 1; Question 20)
Spatial and Storage Capacity	• Size of the stand (Reference: APPENDIX 1; Question 41) • Size of house (Reference: APPENDIX 1; Question 42)

Table 10: Factors influencing the household uptake of Water Sensitive Urban Design measures as featured in the literature review and survey questionnaire

Possible predictors, as identified in the literature review	(Possible predictors) Independent variables as featured in the subject questionnaire and subject study
Situational and Behavioural factors	
Pro-environmental behaviour	The utilisation of various municipal water-saving measures (Reference: APPENDIX 1; Question 25)
Proximity to Water Challenges	Not measured as part of this study. However, survey data from the City of Cape Town, which was identified as a water-stressed area during the time the survey project was conducted, as well as the City of Tshwane, which was, and still is, perceived as relatively less water-stressed (and to some extent water-secure) area, is available. As such, this study examines the proximity factor by comparing results from a water-stressed locale with results from a less water-stressed locale.
Water use restrictions	• Announcement of water use restrictions (Reference: APPENDIX 1; Question 27.b) • Enforcement of water use restrictions (Reference: APPENDIX 1; Question 27.c)
Socio-demographic factors	
Household income	Not measured as part of this study. **Income Area**: Although household income was not featured in the subject questionnaire (Reference: APPENDIX 1) – the areas, i.e. towns, suburbs and townships, from which respondents (i.e. households) for this study were sampled, were classified into broad income categories; namely *Middle* income areas (which predominantly consist of middle income households), *Mixed* income areas (i.e. which consist of a fairly equal distribution of middle and high income households) and *High* income areas (which predominantly consist of high income households). The areas were classified into broad income categories based on subjective property market and value observations.

Table 10: Factors influencing the household uptake of Water Sensitive Urban Design measures as featured in the literature review and survey questionnaire

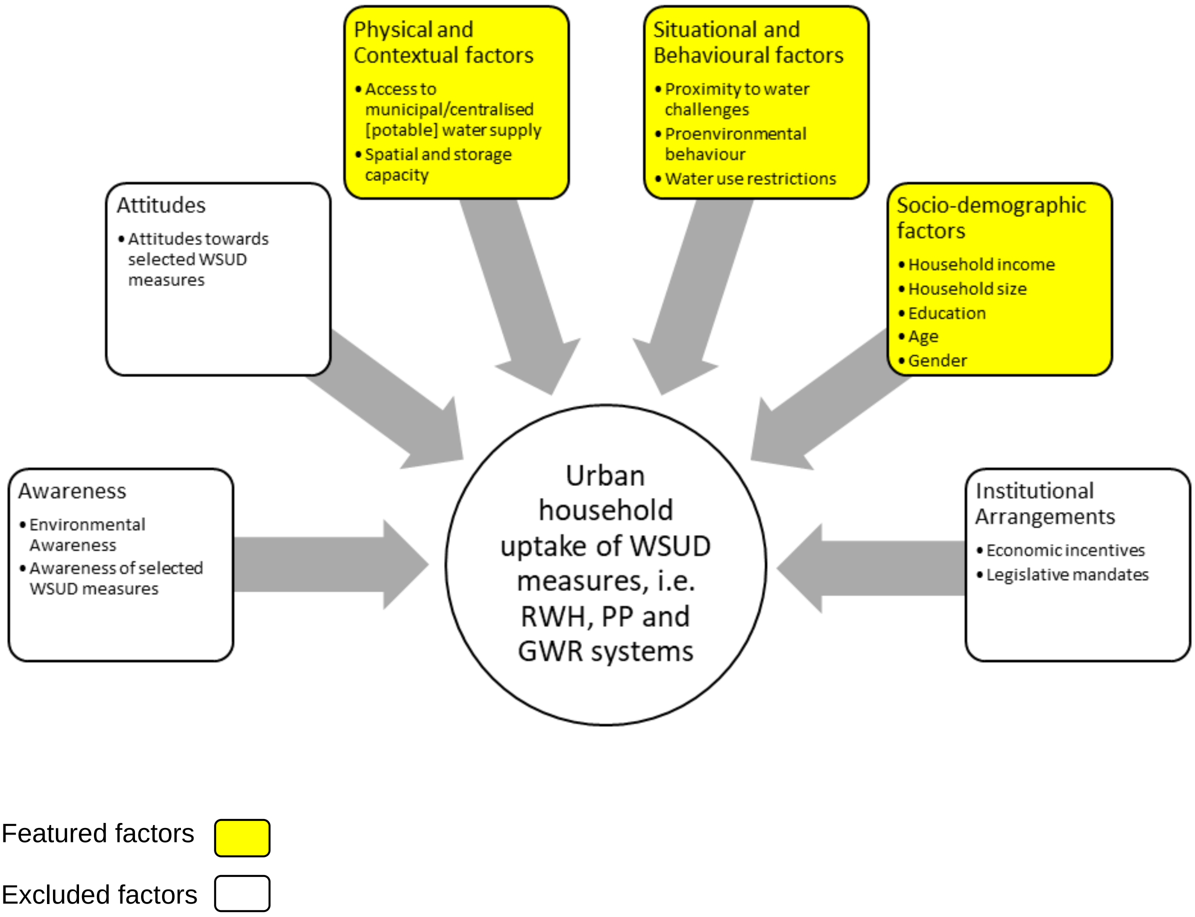
Possible predictors, as identified in the literature review	(Possible predictors) Independent variables as featured in the subject questionnaire and subject study
Household size	Household size (Reference: APPENDIX 1; Question 43)
Education	Highest level of education in the household (Reference: APPENDIX 1; Question 44)
Age	Age of head of household (Reference: APPENDIX 1; Question 46)
Gender	Not measured as part of this study. As indicated on the first page of the survey instrument (APPENDIX 1), g*ender* was measured. However, as deduced from the literature review, the significance of *gender* as a possible predictor is uncertain. Although this study presents an opportunity to examine this factor's significance – it is argued that the presence of additional factors that (to some extent) confine individuals to their homes for relatively long periods, such as unemployment, retirement, remote working and traditional gender roles – which often result in women being homebound, would have provided an incentive to examine and compare the significance of *gender* (i.e. relative to these other factors) as a possible predictor.
Home-ownership status	Home-ownership status (Reference: APPENDIX 1; Question 50)
Institutional Arrangements	
Economic incentives	Not measured as part of this study. Furthermore, *economic incentives* do not apply to the RSA context; The same applies to the respective case area(s).

Table 10: Factors influencing the household uptake of Water Sensitive Urban Design measures as featured in the literature review and survey questionnaire

Possible predictors, as identified in the literature review	(Possible predictors) Independent variables as featured in the subject questionnaire and subject study
Legislative mandates	Not measured as part of this study. As highlighted in Chapter 1.4, several legislative mechanisms that encourage the use of WSUD measures are available; however, legislation that *mandates* the use of the subject measures at the household level is yet to be introduced to the RSA context and the respective case area(s).

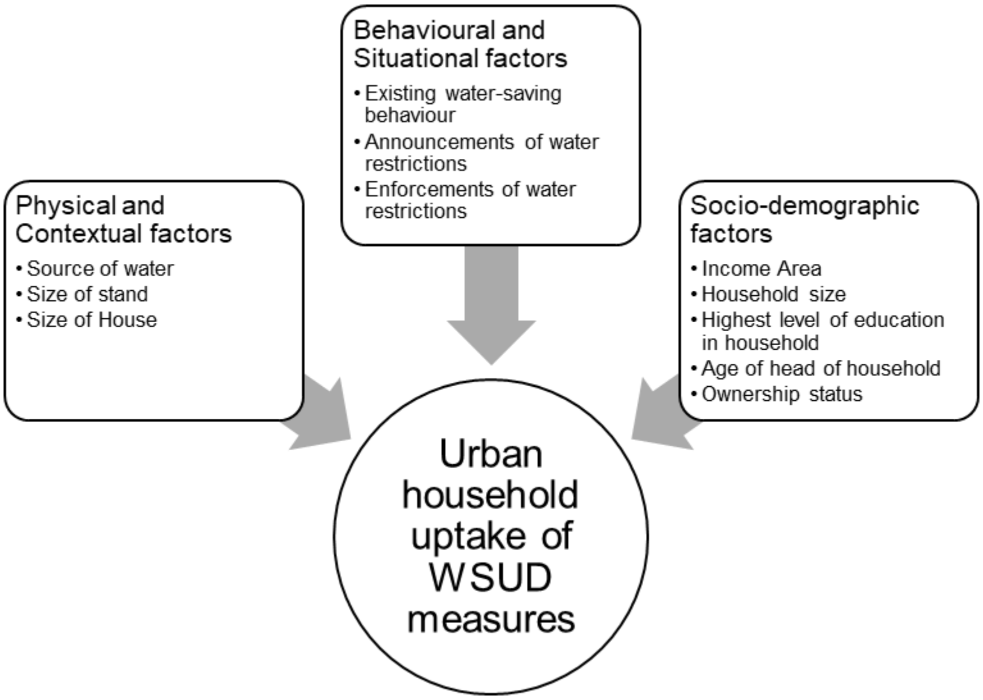
As indicated in Table 10, factors related to *awareness*, *attitudes* as well as *institutional arrangements* did not feature in the subject questionnaire (APPENDIX 1) and were as a result not measured nor analysed as part of this study. As such, only *physical and contextual* factors, *situational and behavioural* factors, as well as *socio-demographic* factors remained. Figure 6(b) illustrates.

Figure 6 (b): Factors influencing household uptake of Water Sensitive Urban Design Measures



Consequently, a framework, as illustrated below (Figure 7), was designed to examine the association between the current uptake of three selected WSUD measures, which include RWH, PP and GWR *systems*, by urban households as well as three sets of factors that may influence the uptake; which are also referred to possible predictors. As outlined in Figure 7, the three sets of possible predictors were identified as *physical and contextual* factors, *situational and behavioural* factors, and *socio-demographic* factors.

Figure 7: Analytical Framework designed to examine the association between household uptake of Water Sensitive Urban Design measures and possible predictors



Therefore, to examine associations – the uptake of selected WSUD measures by urban households was identified as a dependent variable, whereas possible predictors, which, as mentioned, are clustered into the three sets of *contextual and physical* factors, *situational and behavioural* factors, and *socio-demographic* factors, were identified as independent variables. As such, log-linear analyses, Chi-square and Fisher's exact tests, and cross-tabulations between the dependent and independent variables were conducted on SPSS, Version 26. Log-linear analyses were conducted to determine any significant three-way effects (i.e. between the relevant metropolitan area, predictor and household uptake). Chi-square and Fisher's exact tests were conducted to determine significant differences between predictor categories and effect sizes for each predictor using Cramér's *V*.

3.2.4.3. Objective 3

To meet the third research objective, responses from question 14 of the questionnaire (APPENDIX 1) – in which respondents were asked to rank each of the seven listed municipal instruments from most to least effective in terms of causing their households to reduce municipal water use – were analysed. Since respondents were asked to *rank* the various instruments, as opposed to providing a score out of seven for each one, some respondents misinterpreted instructions which resulted in either duplicate or incomplete rankings of items, which were removed from the analysis. The rankings that were analysed were then grouped into three categories, i.e., 'most effective' (if ranked amongst the first three), 'neither effective nor ineffective' (if ranked fourth), and 'least effective' (if ranked amongst the last three) instruments. Frequency and percentage distribution tables, as well as Chi-square tests, were conducted using SPSS, Version 26. For the purpose of this study, frequencies and percentages for instruments ranked 'most effective' were analysed and reported on; whereby the instruments are sorted from the largest to the smallest total percentage (i.e., for the Cities Cape Town and Tshwane combined); Table 24 (as provided for in Chapter 4) illustrates.

3.3. Limitations

This section outlines the limitations associated with this study's methodology, and includes the study's limitations to theory, the questionnaire (APPENDIX 1), as well as the limitations associated with the applicable data collection methods.

3.3.1. Limitations in terms of Theory and Data Analysis

The study's limitations to theory include the lack of theoretical frameworks suitable to study the household uptake of WSUD measures, which this study seeks to address through its second objective, as illustrated in Figure 7. Furthermore, as outlined earlier, the study has a relatively small sample (N=250) and, moreover, all of the study's variables are categorical. Although correct statistical procedures were used to analyse data, procedures are limited to categorical data analysis. However, studies such as this one, i.e. predominantly quantitative studies, or at least Objective 2, usually include interval or ratio variables that are often analysed through multiple regression or structural equation modelling (SEM). Thus highlighting an additional research gap for future studies to address.

3.3.2. Limitations to the Questionnaire

With regards to the limitations linked to the design of the study's questionnaire (APPENDIX 1), several of them were observed. For instance, the designed survey instrument featured 52 questions, in total, with an interview duration of about 40 to 60 minutes. Numerous respondents and fieldworkers perceived this as "too long" and "too comprehensive". Therefore, and although not measured, it was observed in the field that this perception resulted in a relatively high rejection rate. However, the inclusion of close-ended questions, which provide respondents with a list of responses to choose from, attempted to offset this limitation to some extent.

The inclusion of questions that some respondents may have perceived as intrusive is another identified limitation to the design of the survey instrument. With particular reference to the study's questionnaire (APPENDIX 1), examples of questions that some respondents perceived as invasive include inquiries about respondents' age, as well as the highest level of education they had obtained at the time of the survey; these are specified in questions 44 to 47 of the questionnaire. Therefore, it is argued that such questions could result in either inaccurate responses, as a result of concealment from respondents, or a low response rate, i.e. in cases whereby respondents refused to answer the specific questions. Non-contact interviews, such as telephone interviews and self-administered surveys, may encourage respondents to respond to such questions and do so accurately.

The use of foreign concepts was identified as another limitation to the study's questionnaire design. In particular, several specific items in the subject questionnaire were not customised for South African audiences or were rather foreign to most South African householders. Smart metering, as listed in question 14 of the questionnaire (APPENDIX 1), constitutes an example. Although most South Africans are familiar with smart meters for household electricity, smart metering for domestic water consumption is a foreign concept. As a result, several survey fieldworkers were unable to define, describe, or explain such concepts to respondents, further threatening the response rate and the validity of the study's results. As such, the use of graphic aids to illustrate technologies such as smart metering and simplified descriptions to provide respondents with clarity is recommended for future studies in similar predicaments.

The language barrier was identified as another limitation to this study. For example, the questionnaire was designed in English. As a result, in instances whereby respondents were not fluent or unfamiliar with the English language, fieldworkers had to translate the entire questionnaire and conduct the interviews in languages that respondents could communicate in. However, in cases where a fieldworker was unfamiliar with a respondent's home or native language, or whatever language the respondent preferred, the survey interview would then be abandoned, contributing to a low response rate. Therefore, printing out questionnaires in multiple languages that the target population is familiar with and making use of multilingual fieldworkers or interviewers could help minimise the negative impact of such a limitation.

Social desirability bias, which occurs when respondents distort their answers to conform to popular social norms, i.e. by providing responses that they perceive as socially acceptable, as opposed to honest answers – was identified as another limitation to this particular study (Neuman, 2007; Neuman, 2014). For instance, the adoption of pro-environmental behaviour and, in this case, the uptake of WSUD measures may have been perceived as socially desirable in certain contexts. As a result, respondents may have reported the adoption of such behaviour, even if they had not done so at the time of the survey. Alternatively, the use of forced-choice items or close-ended questions – which feature prominently in the study's questionnaire, as well as the self-administration of surveys, and efforts to maintain respondents' anonymity are some of the ways in which social desirability bias could be limited.

3.3.3. Limitations to Data Collection

Regarding the limitations associated with the data collection techniques applied for this particular study, convenient sampling was identified as one of them. Convenient sampling, whereby the primary criteria for selecting cases, or respondents, is that they are easy to reach or readily available, was applied to this study (Neuman, 2014). However, convenient sampling produces nonrepresentative samples, i.e. samples that are not necessarily representative of populations that are being studied in terms of defining characteristics, such as race, income, gender, and distribution, i.e. in terms of their uptake distribution. Moreover, although surveys are about generalisations, the study does not make any claims based on any of the above groups. Furthermore, the purposeful sampling of the neighbourhoods from which the respondents (i.e. households) were conveniently sampled and the delimitations imposed on this study could reduce the limitations imposed on this study as a result of the convenient sampling method.

Interviewer bias – which can arise from an interviewer's expectations based on a respondent's identity or appearance, which may include a respondent's gender, race, or age – was also identified as one of the limitations to this particular study (Neuman, 2014). An example could be a survey interviewer who codes young people as being less informed than their older counterparts. It is also believed that an interviewer's characteristics, including their approach, appearance and tone, can influence a respondent's answers in various ways. As a result, a respondent could reply to identical questions differently depending on an interviewer's features or characteristics, thus threatening the reliability of that particular study (Neuman, 2014). Therefore, and as recommended earlier, the self-administration of surveys could eradicate this particular limitation.

Respondent recall and telescope, or telescoping, were identified as another limitation to this study's data collection methods. For instance, researchers often ask respondents about past behaviours or events; this study was not any different, as illustrated in question 26 of the questionnaire. Respondents often vary in their ability to recall accurately when answering survey questions. Moreover, recalling past events usually takes more time and effort (Neuman, 2014). As such, the few moments often given to respondents to answer a survey question, may not be enough. Moreover, people's ability to recall past events accurately declines quickly over time (Neuman, 2014). For instance, respondents might accurately recall an event that occurred two weeks ago, but only few can accurately recall events that transpired two years ago (Neuman, 2014). Similarly, respondents often telescope, i.e. either compress or expand time, when asked about past events, by either recalling an event earlier (backward telescope) or later (forward telescope) than it actually happened (Neuman, 2014).

For instance, as specified in question 26 of the questionnaire, respondents were asked to indicate whether they used each of the selected WSUD measures 'this time last year', 'now', and whether they thought they would use these 'this time next year'. Thus requiring respondents to recall events that possibly took place a year before the survey interviews were conducted. Furthermore, respondents were also required to forecast events that were likely to occur within a year from when the surveys were conducted, leaving plenty of room for inaccuracies as a result of backward and forward telescoping to occur. Therefore, in such cases, self-administered surveys would come in handy as these would provide respondents with enough time to recall events and respond to questions as accurately as possible.

CHAPTER 4: FINDINGS AND DISCUSSION

The results – as informed by the research objectives – are presented in terms of (1) past, present and future household uptake of selected Water Sensitive Urban Design (WSUD) measures, i.e. rainwater harvesting (RWH), permeable paving (PP) and greywater reuse (GWR) systems; (2) the association between the current uptake of selected WSUD measures, i.e. by households in suburban and satellite areas, and factors that have been found, i.e. in the literature, to have an influence on the household uptake of the relevant measures – also known as possible predictors; and (3) the perceived effectiveness of various municipal water demand-side management (DSM) instruments, i.e. by households, to reduce household use of municipal water, which include *'assistance to implement WSUD measures'*, as outlined in Question 13 of the questionnaire (APPENDIX 1). The findings for each objective – i.e. both in total and in terms of each case area, including the City of Cape Town and the City of Tshwane – are outlined below.

4.1 Past, Present and Future Uptake of Selected Water Sensitive Urban Design Measures

Table 11 shows past, present and future uptake of selected WSUD measures – including RWH, PP and GWR systems. As outlined in Chapter 3, households were asked to indicate whether they used each of the three selected measures *'this time last year'*, *'now'*, and whether they thought they would use them *'this time next year'*. Therefore, for the purpose of this study, responses specified as *'this time last year'* indicate past uptake, while responses specified as *'now'* and *'this time next year'* indicate present and future uptake, respectively. Table 11 indicates the proportion of households using each of the three (3) WSUD measures by municipality (or metropolitan area) and settlement type. Chi-square and Fisher's exact tests were conducted to test for significant differences between the Cities of Cape Town and Tshwane (df = 1). Chi-square tests are based on the likelihood ratio considering small samples, whereas a Fisher's exact test was used where expected counts were < 5.

Table 11: Past, present and future household uptake of Water Sensitive Urban Design measures

	Period	Cape Town Count	Cape Town %	Pretoria Count	Pretoria %	Total Count	Total %	Significance
Suburb								
Rainwater harvesting	Past	44	48.9	16	17.8	60	33.3	*p* < 0.001[a*]
	Present	48	53.3	19	21.1	67	37.2	*p* < 0.001[a*]
	Future	49	54.4	34	37.8	83	46.1	*p* = 0.025[a*]
Permeable paving	Past	4	4.4	15	16.7	19	10.6	*p* = 0.006[a*]
	Present	5	5.6	17	18.9	22	12.2	*p* = 0.005[a*]
	Future	6	6.7	19	21.1	25	13.9	*p* = 0.004[a*]
Greywater reuse systems	Past	44	48.9	19	21.1	63	35.0	*p* < 0.001[a*]
	Present	48	53.3	17	18.9	65	36.1	*p* < 0.001[a*]
	Future	52	57.8	27	30.0	79	43.9	*p* < 0.001[a*]
Combined	Past	62	68.9	38	42.2	100	55.6	*p* < 0.001[a*]
	Present	66	73.3	37	41.1	103	57.2	*p* < 0.001[a*]
	Future	67	74.4	46	51.1	113	62.8	*p* = 0.001[a*]
Township								
	Period	Cape Town Count	Cape Town %	Pretoria Count	Pretoria %	Total Count	Total %	Significance
Rainwater harvesting	Past	2	5.7	0	0.0	2	2.9	*p* = 0.493[b]
	Present	2	5.7	0	0.0	2	2.9	*p* = 0.493[b]
	Future	7	20.0	0	0.0	7	10.0	*p* = 0.011[b*]
Permeable paving	Past	1	2.9	5	14.3	6	8.6	*p* = 0.198[b]
	Present	1	2.9	5	14.3	6	8.6	*p* = 0.198[b]
	Future	1	2.9	6	17.1	7	10.0	*p* = 0.106[b]
Greywater reuse systems	Past	10	28.6	4	11.4	14	20.0	*p* = 0.069[a]
	Present	10	28.6	4	11.4	14	20.0	*p* = 0.069[a]
	Future	10	28.6	5	14.3	15	21.4	*p* = 0.244[a]
Combined	Past	10	28.6	9	25.7	19	27.1	*p* = 0.788[a]
	Present	10	28.6	8	22.9	18	25.7	*p* = 0.584[a]
	Future	11	31.4	9	25.7	20	28.6	*p* = 0.596[a]
Total								
	Period	Cape Town Count	Cape Town %	Pretoria Count	Pretoria %	Total Count	Total %	Significance
Rainwater harvesting	Past	46	36.8	16	12.8	62	24.8	*p* < 0.001[a*]
	Present	50	40.0	19	15.2	69	27.6	*p* < 0.001[a*]
	Future	56	44.8	34	27.2	90	36.0	*p* = 0.004[a*]
Permeable paving	Past	5	4.0	20	16.0	25	10.0	*p* = 0.001[a*]
	Present	6	4.8	22	17.6	28	11.2	*p* = 0.001[a*]
	Future	7	5.6	25	20.0	32	12.8	*p* < 0.001[a*]
Greywater reuse systems	Past	54	43.2	23	18.4	77	30.8	*p* < 0.001[a*]
	Present	58	46.4	21	16.8	79	31.6	*p* < 0.001[a*]
	Future	62	49.6	32	25.6	94	37.6	*p* < 0.001[a*]
Combined	Past	72	57.6	47	37.6	119	47.6	*p* = 0.001[a*]
	Present	76	60.8	45	36.0	121	48.4	*p* < 0.001[a*]
	Future	78	62.4	55	44.0	133	53.2	*p* = 0.003[a*]

*Notes: a Chi-Square Test (Likelihood ratio); b Fisher's Exact Test; * Significant at the 0.05 level.*

Table 11 indicates that, in total, the proportion of households that reported to have taken up one or more of the selected WSUD measures increased from 47.6% in the previous year to 48.4% at the time of the survey and was expected to increase to 53.2% the following year. Therefore, almost half (i.e. 47.6% and 48.4%) of the sampled households in both the Cities of Cape Town and Tshwane, respectively, indicated to have used at least one of the three measures at the time the survey was administered; while more than half (i.e. 53.2%) indicated that they would use at least one of the selected measures the following year. These results thus indicate a reported increase in the adoption of pro-environmental behaviour through the uptake of selected WSUD measures. It would, therefore, be beneficial for municipalities, as well as other water authorities and service providers to look into why this is the case.

As earlier argued by Charalambous et al. (2018) and Schirmer and Dyer (2018) – in addition to the active dissemination of information – surveys on environmental issues and environmental behaviour studies can increase environmental awareness. This could be a possible explanation for this reported and anticipated increase in WSUD uptake. However, it is also important to note that actual uptake might be lower due to social desirability bias – which refers to the tendency to provide “desirable” responses in the presence of interviewers or fieldworkers. In this case, an example of social desirability bias would be a respondent’s tendency to inflate pro-environmental responses – or project pro-environmental behaviour – in the presence of fieldworkers.

Similar findings were observed for sampled households in the City of Cape Town regarding temporal uptake in each of the case areas. For instance, households in the City of Cape Town that reported WSUD uptake increased from 57.6% in the previous year to 60.8% at the time of the survey and was expected to increase to 62.4% the following year; while households in the City of Tshwane reported a decline from 37.6% in the previous year to 36.0% at the time of the survey. However, reported WSUD uptake in Tshwane was expected to increase to 44.0% the following year. These figures further illustrate that considerably larger proportions of households in the City of Cape Town reported past, present, and future uptake of selected WSUD measures, i.e. compared to households in the City of Tshwane; thus, illustrating the possible effect that the imminent day-zero had on households in the City of Cape Town. This is also consistent with findings from an Australian study by Gilbertson et al. (2011), which revealed that water users from a water-scarce region were more likely to engage in water conservation practices (inclusive of WSUD uptake) than those in a water-secure region. Households in the City of Tshwane, however, demonstrated a noticeably higher increase in perceived future uptake. Nevertheless, as outlined above, this increase is from a basis much lower than that of the City of Cape Town.

In terms of the uptake of individual WSUD measures – in total, the order of current WSUD uptake ranges from GWR systems (31.6%) and RWH (27.6%); this is followed by a noticeably lower uptake of PP (11.2%). For the City of Cape Town, a similar pattern was observed, with current WSUD uptake ranging from GWR systems (46.4%) and RWH (40.0%) to PP (4.8%). Conversely, in the City of Tshwane, current WSUD uptake is foremost in terms of PP (17.6%) and is followed by GWR (16.8%) and RWH (15.2%). Therefore, at the time of the survey, significantly larger proportions of households in the City of Cape Town used RWH ($p < 0.001$) and GWR systems ($p < 0.001$), whereas a significantly larger proportion of households in the City of Tshwane had taken up PP ($p = 0.001$).

As noted earlier, spatial capacity is commonly regarded as a prerequisite for PP uptake. The City of Tshwane generally has larger property sizes, on average, compared to the City of Cape Town – which might explain the reported distribution of current PP uptake across the two case areas. An alternative reason for this outcome could be that lawns – which constitute the most common type of PP – often consume significant amounts of water, i.e. through irrigation, and because this activity was restricted as part of the water use restrictions that were introduced and implemented ahead of the then imminent day-zero, households in the City of Cape Town might have been actively avoiding the uptake of PP. In such a case, households may stand to benefit from educational campaigns on the various types of PP available, especially those that do not require water for sustenance.

Alternatively, the misinterpretation of GWR systems as general GWR – which includes the manual collection and conveyance of greywater (i.e. *via* buckets and other containers) for reuse – is another factor that may have modified the results. Thus, RWH may have been the most taken up measure.

In terms of the progression of the actual uptake, for each of the selected WSUD measures, the following was observed: With regards to RWH, the proportion of households, in total, that reported having taken up RWH increased from 24.8% in the previous year to 27.6% at the time of the survey, and was expected to increase to 36.0% the following year. Furthermore, a progressive increase in the uptake of RWH across all three (3) time frames, i.e. past, present, and future, was also revealed for households in the Cities of Cape Town and Tshwane.

For PP, the proportion of households, in total, that reported the uptake of PP increased from 10.0% in the previous year to 11.2% at the time of the survey; this was expected to increase to 12.8% the following year. A similar progressive increase in the uptake of PP across all three (3) time frames – i.e. past, present, and future – was also revealed for households in both the Cities of Cape Town and Tshwane.

Concerning GWR systems, the proportion of households, in total, that reported to have taken up the use of GWR systems increased from 30.8% in the previous year to 31.6% at the time of the survey and was expected to increase to 37.6% the following year. The gradual increase, i.e. across the relevant time frames, in the uptake of GWR systems was also observed for households in the Cities of Cape Town. Conversely, households in the City of Tshwane reported a decrease in uptake from 18.4% in the previous year to 16.8% at the time of the survey; uptake was, however, expected to increase to 25.6% the following year. This may reflect a tendency for water users and households to remain passive on water issues when they do not directly face threats to water security, thus presenting a need to make households and water users proactive, regardless of their water situation.

In terms of the effect of settlement types on the uptake of WSUD measures, uptake was most pronounced in the suburbs. As illustrated in Table 11, in total, more than half the proportion of households in the suburbs and satellite towns (55.6%, 57.2% and 62.8%) respectively reported past, present, and future uptake of selected WSUD measures (i.e. *combined*), compared to the proportion of households in townships (27.1%, 25.7%, and 28.6%). Moreover, while uptake in suburbs (and satellite towns) increased from past (55.6%) to present (57.2%) to future (62.8%), uptake in townships decreased from past (27.1%) to present (25.7%).

Furthermore, significantly larger proportions of suburban households in the City of Cape Town ($p<0.001$; $p<0.001$; $p=0.001$) reported combined past (68.9%), present (73.3%), and future (74.4%) WSUD uptake compared to suburban households in the City of Tshwane (42.2%; 41.1%;51.1%); which again highlights the possible effect of day-zero. However, apart from one item – i.e. the future uptake of RWH; whereby ($p=0.011$) – there are no significant differences in uptake between township households across the City of Cape Town and the City of Tshwane. Therefore, any effect of day-zero is clearly limited to the suburbs and satellite towns. However, the small sample of township households (N=35) increases the probability of sampling error and conclusions that are not necessarily generalisable.

Except for a possible sampling error, the significantly higher uptake of selected WSUD measures in the suburbs and satellite towns – including those situated in contexts characterised by water shortages – can be attributed to the fact that water is often used more diversely in the suburbs than in township areas. For instance, a diverse range of water use activities – such as washing cars, watering gardens and lawns (i.e. irrigation) as well as the filling up swimming pools – which often require significant amounts of water – are predominant in suburban and satellite town) households; whilst water is mainly used for essential purposes in townships. This indicates that suburban households as well as households in satellite towns, might stand to benefit more from taking up selected WSUD measures such as RWH and GWR systems in terms of saving and offsetting their respective municipal and/or potable water use.

4.2 Association Between Current Household Uptake and Possible Predictors

The second research objective results sought to examine the association between current WSUD uptake and factors that may influence uptake, including *contextual and physical*, *behavioural and situational* and *socio-demographic* factors. As such, the association between the various factors that have been found (i.e. in the literature) to have an influence on the household uptake of selected WSUD measures – and which may well influence the uptake of the appropriate measures – by sampled households in the Cities of Cape Town and Tshwane, is discussed in this section.

As noted earlier in Chapter 3, these factors are also referred to as possible predictors. They are, as such, postulated as independent variables, while current WSUD uptake is hypothesized as a dependent variable. Moreover, 'current [or present] uptake', as also noted earlier, refers to whether households used any of the selected WSUD measures – including RWH, PP and GWR – at the time the surveys were conducted, i.e. responses specified under 'now' in Question 26 of the relevant questionnaire (APPENDIX 1).

As outlined in Chapters *2* and 3, six sets of factors that have been found to influence the uptake of selected WSUD measures by urban households were identified. These include factors related to *awareness* and individual *attitudes*, *physical and contextual* factors, *socio-demographic* factors, *situational and behavioural* factors, and factors related to *institutional arrangements*. Moreover, from these six sets, a total of 16 factors – or possible predictors – were identified. However, after these factors were adapted to the contents of the applied survey instrument (APPENDIX 1), only three sets of factors remained. As highlighted in the second research objective, these include *physical and contextual* factors, *situational and behavioural* factors, and *socio-demographic* factors.

Furthermore, the adaptation process resulted in changes to some of the possible predictors. For instance, to measure a household's spatial and storage capacity, **size of stand** and **size of the house** were identified as independent variables, or possible predictors, under the set of *physical and contextual* factors. These changes are illustrated in Chapter 3, i.e. Figure 7, which depicts the analytical framework designed, for the purpose of this study, to examine the association between current household WSUD uptake and the three sets of factors. As such, the results of the examined association are outlined below. However, these are limited to suburbs and satellite towns to control any predictor-related differences between settlement types. The subsamples for townships were too small to conduct separate bivariate analyses.

4.2.1 Physical and Contextual Factors

As illustrated in Figure 7, a household's **source of water** and household's **size of house** and **size of the stand** were identified as *physical and contextual* factors, or rather as possible predictors under the set off *physical and contextual* factors. Results for each of these are presented below.

4.2.1.1 Source of Water

As informed by findings in the literature, households with a general lack of or limited access to municipal and/or centralised potable water supplies are more likely to take up selected WSUD measures – particularly RWH and GWR – to generate and secure water from alternative sources (Owusu & Teye, 2015; Schirmer & Dyer, 2018). As such, Table 12 shows the results for the association between the current household uptake of selected WSUD measures and the relevant households' main source of water for drinking and preparing food, by municipality.

Table 12: Association between household uptake of Water Sensitive Urban Design measures and main source of water by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	**%**	**Count**	**%**	**Count**	**%**
Municipal water	Yes	62	74.7	32	42.1	94	59.1
	No	21	25.3	44	57.9	65	40.9
	Total	**83**	**100.0**	**76**	**100.0**	**159**	**100.0**
Borehole water or other	Yes	4	57.1	5	35.7	9	42.9
	No	3	42.9	9	64.3	12	57.1
	Total	**7**	**100.0**	**14**	**100.0**	**21**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Municipal water	Yes	45	54.2	16	21.1	61	38.4
	No	38	45.8	60	78.9	98	61.6
	Total	**83**	**100.0**	**76**	**100.0**	**159**	**100.0**
Borehole water	Yes	3	42.9	3	21.4	6	28.6
	No	4	57.1	11	78.6	15	71.4
	Total	**7**	**100.0**	**14**	**100.0**	**21**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Municipal water	Yes	5	6.0	15	19.7	20	12.6
	No	78	94.0	61	80.3	139	87.4
	Total	**83**	**100.0**	**76**	**100.0**	**159**	**100.0**
Borehole water	Yes	0	.0	2	14.3	2	9.5
	No	7	100.0	12	85.7	19	90.5
	Total	**7**	**100.0**	**14**	**100.0**	**21**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Municipal water	Yes	45	54.2	14	18.4	59	37.1
	No	38	45.8	62	81.6	100	62.9
	Total	**83**	**100.0**	**76**	**100.0**	**159**	**100.0**
Borehole water	Yes	3	42.9	3	21.4	6	28.6
	No	4	57.1	11	78.6	15	71.4
	Total	**7**	**100.0**	**14**	**100.0**	**21**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As illustrated in Table 12, in total – a larger proportion of households (59.1%) that rely on municipal water for drinking and preparing food had taken up one or more of the WSUD measures at the time of the survey. This was observed in comparison to households that rely on borehole water or other water sources for drinking and preparing food, whereby a relatively smaller proportion of households (42.9%) had taken up one or more of the WSUD measures. The same trend was observed for households across both the Cities of Cape Town and Tshwane.

With particular regards to RWH and GWR systems, similar findings were observed, whereby a larger proportion of households that rely on municipal water (38.4% and 37.1%) had taken up RWH and GWR systems, respectively; while a smaller proportion of households that rely on borehole or other sources of water (28.6% and 28.6%) had taken up the two measures. The same trend was observed for households in the City of Cape Town. In contrast, no considerable differences were observed for households in the City of Tshwane – whereby an equal proportion of households relying on both municipal (21.1% and 18.4%) and other sources of water (21.4% and 21.4%) reported to have taken up RWH or GWR systems at the time of the survey.

Therefore, contrary to the study's hypothesis – as based on Mason et al.'s (2018) and Owusu and Teye's (2015) findings – households that rely on municipal and/or centralised potable water, as opposed to those that rely on alternative sources of water, are more likely to take up selected WSUD measures, particularly RWH and GWR systems. The reason for this could be linked to the unreliability – as demonstrated through the implementation of water cuts and water use restrictions – and cost(s) associated with municipal water. Therefore, in such instances, households are more likely to find alternative means of securing enough water to meet demand and curb the cost(s) of municipal water.

However, results do not necessarily disprove the findings by Owusu and Teye (2015) and Mason et al. (2018). For instance, households' use of boreholes (i.e. groundwater) might be a choice – as driven by the perceived independence from potable water sources and municipal services, which (as partly shaped by events surrounding the City of Cape Town's day-zero) might be perceived by some as volatile – as opposed to being a consequence of limited access to the municipal or centralised potable water supply. Furthermore, households that rely on water from boreholes as their main sources of water for drinking and preparing food may perceive themselves as immune to water challenges; thus forgetting, or in some cases unaware of, the fact that groundwater tables need to be recharged – typically through the uptake or installation of PP, which as indicated in Table 11, was the least taken up WSUD measure at the time of the survey.

4.2.1.2 Size of Stand

A household's spatial and storage capacity – which is now expressed in terms of 'size of house' and 'size of stand' – emerged in the existing body of knowledge as a possible predictor for a household's uptake of selected WSUD measures. In particular, the key argument is that households with the capacity to take up (i.e. install, retrofit, operate and maintain) the infrastructure and technology associated with selected measures are more likely to take up the measures in question (Cote & Wolfe, 2014; Brown et al., 2008). Moreover, based on the assumption that households residing in relatively larger houses and with bigger yards have an inherent demand for more water – i.e. the larger the size of the house (i.e. dwelling) and residential stand, the greater the demand for water – they are likely to find various means of securing enough water (usually through alternative sources) to offset demand and to ultimately curb costs for municipal water. As such, Table 13 shows results for the association between the current household uptake of selected WSUD measures and the size of the stand (i.e. yard; residential property) by municipality.

Table 13: Association between household uptake of Water Sensitive Urban Design measures and size of stand by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	%	Count	%	Count	%
Smaller than 1001 sq m	Yes	29	82.9	6	33.3	35	66.0
	No	6	17.1	12	66.7	18	34.0
	Total	**35**	**100.0**	**18**	**100.0**	**53**	**100.0**
Larger than 1000 sq m	Yes	12	66.7	22	46.8	34	52.3
	No	6	33.3	25	53.2	31	47.7
	Total	**18**	**100.0**	**47**	**100.0**	**65**	**100.0**
Rainwater harvesting							
		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Smaller than 1001 sq m	Yes	23	64.7	4	22.2	27	50.9
	No	12	34.3	14	77.8	26	49.1
	Total	**35**	**100.0**	**18**	**100.0**	**53**	**100.0**
Larger than 1000 sq m	Yes	11	61.1	10	21.3	21	32.3
	No	7	38.9	37	78.7	44	67.7
	Total	**18**	**100.0**	**47**	**100.0**	**65**	**100.0**
Permeable paving							
		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Smaller than 1001 sq m	Yes	3	8.6	3	16.7	6	11.3
	No	32	91.4	15	83.3	47	88.7
	Total	**35**	**100.0**	**18**	**100.0**	**53**	**100.0**
Larger than 1000 sq m	Yes	1	5.6	8	17.0	9	13.8
	No	17	94.4	39	83.0	56	86.2
	Total	**18**	**100.0**	**47**	**100.0**	**65**	**100.0**
Greywater reuse systems							
		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Smaller than 1001 sq m	Yes	17	48.6	3	16.7	20	37.7
	No	18	51.4	15	83.3	33	62.3
	Total	**35**	**100.0**	**18**	**100.0**	**53**	**100.0**
Larger than 1000 sq m	Yes	10	55.6	10	21.3	20	30.8
	No	8	44.4	37	78.7	45	69.2
	Total	**18**	**100.0**	**47**	**100.0**	**65**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As illustrated in Table 13, in total, a larger proportion of households with relatively smaller stand sizes (66.0%) – i.e. less than 1001m^2 – reported to have taken up one or more of the selected WSUD measures, while a relatively smaller proportion of households with larger stand sizes (52.3%) – i.e. more than 1000m^2 – reported to have done the same. The same trend was observed for households in the City of Cape Town. However, the opposite was observed for households in the City of Tshwane – whereby a larger proportion of households with relatively larger stand sizes (46.8%) reported having taken up selected WSUD measures compared to 33.3% of households with smaller stand sizes.

In terms of RWH and GWR systems, similar trends were observed as larger proportions of households with smaller stand sizes (59.9% and 37.7%) reported to have taken up RWH and GWR systems, respectively, at the time of the survey. This is compared to 32.2% and 30.8% of households with larger stand sizes that reported to have done the same. The same trend was observed for households across the Cities of Cape Town and Tshwane for RWH and an inverse was observed for GWR systems. In terms of PP, findings were revealed to be consistent with the literature as a slightly larger proportion of households with larger stand sizes (13.8%) reported to have taken up PP at the time of the survey, while a somewhat smaller proportion of households with relatively smaller stand sizes (11.3%) reported to have done the same. The same trend was observed for households in the City of Tshwane, while the opposite was observed for households in the City of Cape Town.

Therefore, except for households in the City of Tshwane and the uptake of GWR systems in the City of Cape Town, results are generally not consistent with the literature. This could be explained by the effect of a then imminent day-zero – whereby the effects of water shortage were felt by all, or rather a majority of the households, in the City of Cape Town, regardless of property sizes. Moreover, compared to other selected WSUD measures, a household’s uptake of PP is highly dependent on its spatial capacity, i.e. the availability of surface area. As revealed, the uptake of PP was most pronounced by households with larger houses and larger stand sizes, in particular.

4.2.1.3. Size of House

Table 14 shows the results for the association between the current household uptake of selected WSUD measures and the size of the house (dwelling) by municipality.

Table 14: Association between household uptake of Water Sensitive Urban Design measures and size of house by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	**%**	**Count**	**%**	**Count**	**%**
Smaller than 241 sq m	Yes	23	23.1	3	23.1	26	63.4
	No	5	76.9	10	76.9	15	36.6
	Total	**28**	**100.0**	**13**	**100.0**	**41**	**100.0**
Larger than 240 sq m	Yes	15	78.9	21	45.7	36	55..4
	No	4	21.1	25	54.3	29	44.6
	Total	**19**	**100.0**	**46**	**100.0**	**65**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Smaller than 241 sq	Yes	18	64.3	0	.0	18	43.9
	No	10	35.7	13	100.0	23	56.1
	Total	**28**	**100.0**	**13**	**100.0**	**41**	**100.0**
Larger than 240 sq m	Yes	13	68.4	13	28.3	26	40.0
	No	6	31.6	33	71.7	39	60.0
	Total	**19**	**100.0**	**46**	**100.0**	**65**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Smaller than 241 sq m	Yes	1	3.6	1	7.7	2	4.9
	No	27	96.4	12	92.3	39	95.1
	Total	**28**	**100.0**	**13**	**100.0**	**41**	**100.0**
Larger than 240 sq m	Yes	2	10.5	8	17.4	10	15.4
	No	17	89.5	38	82.6	55	84.6
	Total	**19**	**100.0**	**46**	**100.0**	**65**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Smaller than 241 sq m	Yes	13	46.4	2	15.4	15	36.6
	No	15	53.6	11	84.6	26	63.4
	Total	**28**	**100.0**	**13**	**100.0**	**41**	**100.0**
Larger than 240 sq m	Yes	12	63.2	8	17.4	20	30.8
	No	7	36.8	38	82.6	45	69.2
	Total	**19**	**100.0**	**46**	**100.0**	**65**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As Table 14 illustrates, a larger proportion of households with dwelling sizes smaller than 241m^2 (63.4%) reported having taken up one or more of the selected WSUD measures at the time of the survey. However, although smaller in proportion, more than half (55.4%) of households with dwelling sizes greater than 240m^2 also reported to have taken up one or more of the measures in question.

However, inverse results were observed for households across both the Cities of Cape Town and Tshwane, respectively, whereby larger proportions of households (78.9% and 45.7%)

with large dwelling sizes reported having taken up selected WSUD measures; this is in comparison to the lower proportions of households across the City of Cape Town (23.1%) and the City of Tshwane (23.2%) with relatively smaller dwelling sizes that reported the same.

Similar trends were observed for RWH and GWR systems in particular. For instance, in total, larger proportions of households with relatively smaller dwelling sizes (43.9% and 36.6%) reported having taken up RWH and GWR systems, respectively, while slightly smaller proportions of households in larger dwellings (40.3% and 30.8 %) reported the same. The inverse, however, was observed across each of the case areas, whereby larger proportions of households with larger dwellings across both the Cities of Cape and Tshwane reported having taken up RWH (68.4% and 28.3%) and GWR systems (63.2% and 17.4%) respectively; as opposed to those with relatively smaller dwellings, whereby comparatively smaller proportions thereof reported to have taken up RWH (64.3% and 0%) and GWR systems (46.4% and 15.4%), respectively, across both case areas.

Therefore, results in each of the case areas are thus consistent with the relevant hypothesis, as deduced from the existing body of knowledge, as well as the assumption that households in large dwellings typically have greater water needs and are, as a result, more likely to take up selected WSUD measures, particularly RWH and GWR systems, in an attempt to offset their considerable demand for potable water and to save costs.

With regards to the current uptake of PP, in total, households with relatively larger dwelling sizes reported having taken up PP. This occurrence was also observed for households across the Cities of Cape Town and Tshwane. Therefore, this might indicate the significance of a household's spatial capacity as a predictor of PP uptake.

4.2.2 Situational and Behavioural Factors

As part of the *situational and behavioural* factors, a household's **use of existing municipal water-saving measures** and a household's cognizance of the **announcement and enforcement of municipal water use restrictions** were identified as possible predictors. Results for each of these are presented below.

4.2.2.1. *Use of Existing Municipal Water-Saving Measures*

As informed by existing literature, households that exhibit pro-environmental behaviour are more likely to take up selected WSUD measures than those that do not (Amodeo & Francis, 2019; Schirmer & Dyer, 2018). As such, for the purpose of this study, a household's use of existing municipal water-saving measures – which, as illustrated in Question 26 of the survey instrument (APPENDIX 1), include constant flow regulators, smart metering, water-saving showerheads, dual-flush toilets, eco-settings on appliances, timed sprinklers, manual greywater reuse, and 'other' – was used to determine existing pro-environmental behaviour. As such, Table 15 shows results for the association between the current household uptake of WSUD measures and the number of water-saving measures used by the relevant households, i.e. by the municipality; with the key hypothesis being that the more water-saving measures a household uses, the more likely that household is to take up selected WSUD measures.

Table 15: Association between household uptake of Water Sensitive Urban Design measures and size of stand by municipality (suburbs and satellite towns only) and number of water-saving measures

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	**%**	**Count**	**%**	**Count**	**%**
None	Yes	6	37.5	3	11.1	9	20.9
	No	10	62.5	24	88.9	34	79.1
	Total	**16**	**100.0**	**27**	**100.0**	**43**	**100.0**
One or two	Yes	36	80.0	14	46.7	50	66.7
	No	9	20.0	16	53.3	25	33.3
	Total	**45**	**100.0**	**30**	**100.0**	**75**	**100.0**
Three or more	Yes	24	82.8	20	60.6	44	71.0
	No	5	17.2	13	39.4	18	29.0
	Total	**29**	**100.0**	**33**	**100.0**	**62**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
None	Yes	4	25.0	2	7.4	6	14.0
	No	12	75.0	25	92.6	37	86.0
	Total	**16**	**100.0**	**27**	**100.0**	**43**	**100.0**
One or two	Yes	26	57.8	10	33.3	36	48.0
	No	19	42.2	20	66.7	39	52.0
	Total	**45**	**100.0**	**30**	**100.0**	**75**	**100.0**
Three or more		18	62.1	7	21.2	25	40.3
		11	37.9	26	78.8	37	59.7
		29	**100.0**	**33**	**100.0**	**62**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
None	Yes	1	6.2	3	11.1	4	9.3
	No	15	93.8	24	88.9	39	90.7
	Total	**16**	**100.0**	**27**	**100.0**	**43**	**100.0**
One or two	Yes	1	2.2	7	23.3	8	10.7
	No	44	97.8	23	76.7	67	89.3
	Total	**45**	**100.0**	**30**	**100.0**	**75**	**100.0**
Three or more	Yes	3	10.3	7	21.2	10	16.1
	No	26	89.7	26	78.8	52	83.9
	Total	**29**	**100.0**	**33**	**100.0**	**62**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
None	Yes	4	25.0	2	7.4	6	10.0
	No	12	75.0	25	92.6	37	86.0
	Total	**16**	**100.0**	**27**	**100.0**	**43**	**100.0**
One or two	Yes	27	60.0	5	16.7	32	42.7
	No	18	40.0	25	83.3	43	57.3
	Total	**45**	**100.0**	**30**	**100.0**	**75**	**100.0**
Three or more	Yes	17	58.6	10	30.3	27	43.5
	No	12	41.4	23	69.7	35	56.5
	Total	**29**	**100.0**	**33**	**100.0**	**62**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As Table 15 indicates, in total, the proportion of households reported having taken up one or more of the selected WSUD measures increased with the number of water-saving measures that the sampled households reported to have been using at the time of the survey. For instance, the largest proportion of households that reported to have taken up one or more of the selected WSUD measures, reported to have been using three or more water-saving measures (71.0%) at the time of the survey. This was followed by households that reported to have been using one or two water-saving measures (66.7%) and households that reported to have been using no water-saving measures (20.9%). The same trend was observed for households in both the Cities of Cape Town and Tshwane.

With regards to the current household uptake of RWH – in total, as well as across both the Cities of Cape Town and Tshwane, the proportion of households that reported to have taken up RWH also increased with the number of water-saving measures the sampled households reported to have been using at the time of the survey. Moreover, with the current household uptake of GWR systems in the City of Cape Town as an exception – whereby uptake was most pronounced by households that reported to have been using one or two municipal water-saving measures (60.0%) at the time of the survey, which was followed by households that reported to have been using three or more municipal water-saving measures (58.6%) and none of the measures (25%) – similar trends were observed for GWR systems across all households.

With regards to the current household uptake of PP, in total, the current household uptake of PP increased with an increase in the number of water-saving measures that households reported to have been using. For instance, 83.9% of households reported to have taken up PP, also reported to have been utilising three or more water-saving measures at the time of the survey. This was followed by 10.7% of households that reported to have taken up PP while utilising one or two water-saving measures and 9.3% of households that reported to have taken up PP while using none of the water-saving measures. Few exceptional cases across the Cities of Cape Town and Tshwane were observed; however, these do not necessarily dismiss the hypothesis presented because, across all case areas, households that reported to have been using at least one of the municipal water-saving measures also reported having taken up one or more of the selected WSUD measures. Therefore, the use of existing municipal water-saving measures appears to be a strong and possibly significant predictor of WSUD uptake.

4.2.2.2. Announcement of Water Use Restrictions

With regards to the announcement and enforcement of water use restrictions, key findings in the literature suggest that households that are cognizant and affected by the announcement and enforcement of water use restrictions, are more likely to adopt or take up selected WSUD measures, particularly RWH and GWR systems – in an effort to minimise the impact(s) thereof, i.e. the impact of water use restrictions (Pinto & Maheshwari, 2010; Campisano et al., 2017). Table 16 shows the results for the association between the current household uptake of selected WSUD measures and whether water use was influenced by the announcement of water restrictions, by municipality.

Table 16: Association between household uptake of Water Sensitive Urban Design measures and whether water use was influenced by the announcement of water use restrictions by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	46	78.0	16	66.7	62	74.7
	No	13	22.0	8	33.3	21	25.3
	Total	**59**	**100.0**	**24**	**100.0**	**83**	**100.0**
No	Yes	8	66.7	5	45.5	13	56.5
	No	4	33.3	6	54.5	10	43.5
	Total	**12**	**100.0**	**11**	**100.0**	**23**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	30	50.8	7	29.2	37	44.6
	No	29	49.2	17	70.8	46	55.4
	Total	**59**	**100.0**	**24**	**100.0**	**83**	**100.0**
No	Yes	6	50.0	3	27.3	9	39.1
	No	6	50.0	8	72.7	14	60.9
	Total	**12**	**100.0**	**11**	**100.0**	**23**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	5	8.5	9	37.5	14	16.9
	No	54	91.5	15	62.5	69	83.1
	Total	**59**	**100.0**	**24**	**100.0**	**83**	**100.0**
No	Yes	0	.0	2	18.2	2	8.7
	No	12	100.0	9	81.8	21	91.3
	Total	**12**	**100.0**	**11**	**100.0**	**23**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	34	57.6	7	29.2	41	49.4
	No	25	42.4	17	70.8	42	50.6
	Total	**59**	**100.0**	**24**	**100.0**	**83**	**100.0**
No	Yes	6	50.0	2	18.2	8	34.8
	No	6	50.0	9	81.8	15	65.2
	Total	**12**	**100.0**	**11**	**100.0**	**23**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column

As indicated in Table 16, in total, a larger proportion of households (74.7%) that reported to have taken up one or more of the selected WSUD measures also reported that the announcement of water use restrictions had influenced their respective water use. This was observed compared to a relatively smaller proportion of households that also reported WSUD uptake while noting that water restrictions did not influence their respective water use (56.5%). The same trend was observed for households in the Cities of Cape Town and Tshwane.

With regards to the current household uptake of RWH, PP and GWR systems – larger proportions of households (44.6%, 16.9% and 49.4%) that reported to have taken up RWH, PP, and GWR systems, respectively, also reported that the announcement of water use restrictions had influenced their respective water use. Relatively smaller proportions of households (39.0%, 8.7% and 34.7%) that reported to have taken up RWH, PP and GWR systems, respectively, noted that the announcement of water restrictions did not influence their respective water use. This was also observed for households across both the Cities of Cape Town and Tshwane, i.e. for each WSUD measure.

Therefore, the announcement of water use restrictions appears to have influenced the household uptake of selected WSUD measures, particularly RWH and GWR systems – which yield alternative water sources and ultimately assist households by offsetting the limitations imposed by water use restrictions. Therefore, municipalities, water authorities and potable water service providers alike could consider introducing water use restrictions in an effort to encourage households to take up selected WSUD measures. Moreover, the relatively high uptake of selected WSUD measures in the City of Cape – which can be regarded as a best planning, or management, practice (BPP/BMP) – possibly indicates the effectiveness of introducing severe water use restrictions to encourage, whether directly or indirectly, the household uptake of selected WSUD measures.

4.2.2.3. Enforcement of Water Use Restrictions

Table 17 shows the results for the association between the current household uptake of selected WSUD measures and whether household water use was influenced by the enforcement of water restrictions, by municipality.

Table 17: Association between household uptake of Water Sensitive Urban Design measures and whether water use was influenced by the enforcement of water use restrictions by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Combined							
Yes	Yes	27	77.1	6	54.5	33	71.7
	No	8	22.9	5	45.5	13	28.3
	Total	**35**	**100.0**	**11**	**100.0**	**46**	**100.0**
No	Yes	28	77.8	14	60.9	42	71.2
	No	8	22.2	9	39.1	17	28.8
	Total	**36**	**100.0**	**23**	**100.0**	**59**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	15	42.9	5	45.5	20	43.5
	No	20	57.1	6	54.5	26	565
	Total	**35**	**100.0**	**11**	**100.0**	**46**	**100.0**
No	Yes	22	61.1	5	21.7	27	45.8
	No	14	38.9	18	78.3	32	54.2
	Total	**36**	**100.0**	**23**	**100.0**	**59**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	4	11.4	4	36.4	8	17.4
	No	31	88.6	7	63.6	38	82.6
	Total	**35**	**100.0**	**11**	**100.0**	**46**	**100.0**
No	Yes	1	2.8	7	30.4	8	13.6
	No	35	97.2	16	69.6	51	86.4
	Total	**36**	**100.0**	**23**	**100.0**	**59**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Yes	Yes	20	57.1	0	.0	20	43.5
	No	15	42.9	11	100.0	26	56.5
	Total	**35**	**100.0**	**11**	**100.0**	**46**	**100.0**
No	Yes	21	58.3	8	34.8	29	49.2
	No	15	41.7	15	65.2	30	50.8
	Total	**36**	**100.0**	**23**	**100.0**	**59**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As Table 17 indicates, in total, 71.7% of households that indicated that the enforcement of water use restrictions influenced their respective water use reported to have taken up one or more of the selected WSUD measures. An approximately equal proportion of households (71.2%) that indicated that the enforcement water restrictions had no influence on their respective water use, also reported the current uptake of selected WSUD measures. The same trend was observed for households in the City of Cape Town.

For the City of Tshwane, a larger proportion of households that noted a lack of influence of the enforcement of water use restrictions on their respective water use (60.9%) reported having taken up one or more of the selected WSUD measures, while a relatively smaller proportion of households that confirmed the influence of the enforcement of water use restrictions on their respective water use (54.5%) reported the same. Similarly, and with regards to the current household uptake of RWH and GWR systems, larger proportions of households that noted a lack of influence of the enforcement of water use restrictions on their respective water use (45.8% and 49.2%), reported to have taken up RWH and GWR systems, respectively, at the time of the survey; while a slightly smaller proportion of households that confirmed the influence of the enforcement of water use restrictions on their respective water use (43.5% and 43.5%) reported the same. This trend was observed for households in the City of Cape Town, while the opposite was observed for households in the City of Tshwane.

With regards to the current household uptake of PP, a relatively larger proportion of households that confirmed the influence of the enforcement of water use restrictions on their respective water use (16.9%) reported to have taken up PP, while a relatively smaller proportion of households (8.7%) that noted a lack of influence of the enforcement of water use restrictions on their respective water use reported the same. The same trend was observed for households in the Cities of Cape Town and Tshwane. Therefore, unlike the announcement of water use restrictions, the enforcement thereof does not seem to have had a noticeable influence on the household uptake of selected WSUD measures. This could reflect the possible ineffectiveness of enforcement measures in each of the case areas, or respondents may have simply misunderstood the concept of enforcement, which may have consequently conflated the results.

4.2.3 Socio-demographic Factors

As part of the *socio-demographic* factors, a household's **income area**, **size**, household members' highest **level of education**, the **age** of the head of the household and the home-**ownership status** were identified. Results for each of these possible predictors are discussed below.

4.2.3.1. Income Area

Households with higher incomes are more likely to take up selected WSUD measures than those with relatively low incomes, as deduced from the literature (Barthwal et al., 2014; Cote & Wolfe, 2014; Baiyegunhi, 2015). However, as a result of the limitations imposed by the survey instrument from which this study's findings derive, reference is made to income area – i.e. the areas from which the sampled households were situated at the time of the survey, whereby the predominant household income of the respective areas is depicted – as a substitute for household income. As such, Table 18 shows results for the association between the current household uptake of selected WSUD measures and income area, by municipality. Notably, because the analysis was limited to suburban (and satellite town) households, the category of 'low-income' was excluded due to it not being represented in the results.

Table 18: Association between household uptake of Water Sensitive Urban Design measures and income area by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	%	Count	%	Count	%
Middle	Yes	6	54.5	15	33.3	21	37.5
	No	5	45.5	30	66.7	35	62.5
	Total	**11**	**100.0**	**45**	**100.0**	**56**	**100.0**
Mixed (middle-high)	Yes	54	77.1	17	48.6	71	67.6
	No	16	22.9	18	51.4	34	32.4
	Total	**70**	**100.0**	**35**	**100.0**	**105**	**100.0**
High	Yes	6	66.7	5	50.0	11	57.9
	No	3	33.3	5	50.0	8	42.1
	Total	**9**	**100.0**	**10**	**100.0**	**19**	**100.0**
Rainwater harvesting							
		Count	%	Count	%	Count	%
Middle	Yes	4	36.4	9	20.0	13	23.2
	No	7	63.6	36	80.0	43	76.8
	Total	**11**	**100.041.4**	**45**	**100.0**	**56**	**100.0**
Mixed (middle-high)	Yes	41	58.6	7	20.0	48	45.7
	No	29	41.4	28	80.0	57	54.3
	Total	**70**	**100.0**	**35**	**100.0**	**105**	**100.0**
High	Yes	3	33.3	3	30.0	6	31.6
	No	6	66.7	7	70.0	13	68.4
	Total	**9**	**100.0**	**10**	**100.0**	**19**	**100.0**
Permeable paving							
		Count	%	Count	%	Count	%
Middle	Yes	0	.0	8	17.9	8	14.3
	No	11	100.0	37	82.1	48	85.7
	Total	**11**	**100.0**	**45**	**100.0**	**56**	**100.0**
Mixed (middle-high)	Yes	3	4.3	6	17.1	9	8.6
	No	67	95.7	29	82.9	96	91.4
	Total	**70**	**100.0**	**35**	**100.0**	**105**	**100.0**
High	Yes	2	22.2	3	30.0	5	26.3
	No	7	77.8	7	70.0	14	73.7
	Total	**9**	**100.0**	**10**	**100.0**	**19**	**100.0**
Greywater reuse systems							
		Count	%	Count	%	Count	%
Middle	Yes	6	54.5	9	20.0	15	26.8
	No	5	45.5	36	80.0	41	73.2
	Total	**11**	**100.0**	**45**	**100.0**	**56**	**100.0**
Mixed (middle-high)	Yes	39	55.7	7	20.0	46	43.8
	No	31	44.3	28	80.0	59	56.2
	Total	**70**	**100.0**	**35**	**100.0**	**105**	**100.0**
High	Yes	3	33.3	1	10.0	4	21.1
	No	6	66.7	9	90.0	15	78.9
	Total	**9**	**100.0**	**10**	**100.0**	**19**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As Table 18 indicates, in total, the largest proportion of households reported to have taken up one or more of the selected WSUD measures at the time of the survey were situated in the middle to high-income areas (67.2%). This was followed by households situated in high-income areas (57.9%), while the smallest proportion of households that reported the current uptake of selected WSUD measures were situated in middle-income areas (37.5%). The same trend was observed for households across the City of Cape Town, while households located in high-income areas constituted the largest proportion of households that reported the current uptake of selected WSUD measures in the City of Tshwane.

With regards to the current household uptake of RWH and GWR systems, in total, the largest proportions of households that reported to have taken up RWH and GWR systems at the time of the survey were situated in the middle to high-income areas (45.7% and 43.8%), respectively. Households across the City of Cape Town (58.6% and 55.7%) reported the same trend, while the largest proportion of households that reported to have taken up RWH across the City of Tshwane (30%) resided in high-income areas.

For PP, in total and across both the Cities of Cape Town and Tshwane – the largest proportion of households that reported to have taken up PP at the time of the survey were situated in high-income areas (26.3%, 22.2% and 30.0%). Moreover, across both the Cities of Cape Town and Tshwane, the least proportion of households that reported to have taken PP, were situated in middle income areas (0% and 17.9%, respectively); which denote the lowest income group found in the suburban areas and satellite towns that were sampled for this study.

Therefore, for all three WSUD measures and across both case areas, the largest proportions of households that reported to have taken up the measures in question commonly resided in either high or middle to high income groups. Therefore, to some extent, these results are consistent with the findings from the studies by Barthwal et al. (2014), Cote and Wolfe (2014), as well as Baiyegunhi (2015). However, households in middle to high income areas emerged as the largest group that reported to have taken up selected WSUD measures. Since middle to high income areas are still inclusive of high-income households, the findings do not necessarily disprove the relevant hypothesis. Alternatively, households in (very) high-income suburbs or residential developments were probably more reluctant or restricted to install aesthetically unattractive features such as RWH tanks or retrofitted plumbing; and as highlighted by Hayden et al. (2015), "…it is crucial to recognise…how important aesthetics are relative to other factors such as water conservation…" (Hayden et al., 2015, p. 2)

The findings thus indicate the possible effect that a household's income has on its ability and/or willingness to take up selected WSUD measures. This also further indicates that lower income households, municipalities and other water authorities could benefit from the provision of financial incentives to encourage and even out the household uptake of selected WSUD measures across households from all income groups. However, the use of income area, which represents the average household income in a specific area – as opposed to individual household income, may have conflated the results.

4.2.3.2. Household Size

With regards to household size, the key argument emerging from the literature is that in comparison to smaller households, larger households are more likely to take up selected WSUD measures, particularly RWH and GWR, as a means to secure alternative sources of water in an effort to meet the demand generated by the respective households' sizeable members (Mason, et al., 2018). As such, Table 19 shows results for the association between the current household uptake of WSUD measures and household size, by municipality.

Table 19: Association between household uptake of Water Sensitive Urban Design measures and household size by municipality (suburbs and satellite towns only)

Combined

		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Small/single parent (1-3 members)	Yes	31	77.5	13	33.3	44	55.7
	No	9	22.5	26	66.7	35	44.3
	Total	**40**	**100.0**	**39**	**100.0**	**79**	**100.0**
Average/nuclear (4 members)	Yes	20	69.0	6	27.3	26	51.0
	No	9	31.0	16	72.7	25	49.0
	Total	**29**	**100.0**	**22**	**100.0**	**51**	**100.0**
Extended (More than 4 members) and multiple families	Yes	15	71.4	17	65.4	32	68.1
	No	6	28.6	9	34.6	15	31.9
	Total	**21**	**100.0**	**26**	**100.0**	**47**	**100.0**

Rainwater harvesting

		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Small/single parent (1-3 members)	Yes	25	62.5	5	12.8	30	38.0
	No	15	37.5	34	87.2	49	62.0
	Total	**40**	**100.0**	**39**	**100.0**	**79**	**100.0**
Average/nuclear (4 members)	Yes	12	41.4	3	13.6	15	29.4
	No	17	58.6	19	86.4	36	70.6
	Total	**29**	**100.0**	**22**	**100.0**	**51**	**100.0**
Extended (More than 4 members) and multiple families	Yes	11	52.4	10	38.5	21	44.7
	No	10	47.6	16	61.5	26	55.3
	Total	**21**	**100.0**	**26**	**100.0**	**47**	**100.0**

Permeable paving

		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Small/single parent (1-3 members)	Yes	1	2.5	7	17.9	8	10.1
	No	39	97.5	32	82.1	71	89.9
	Total	**40**	**100.0**	**39**	**100.0**	**79**	**100.0**
Average/nuclear (4 members)	Yes	4	13.8	3	13.6	7	13.7
	No	25	86.2	19	86.4	44	86.3
	Total	**29**	**100.0**	**22**	**100.0**	**51**	**100.0**
Extended (More than 4 members) and multiple families	Yes	0	.0	7	26.9	7	14.9
	No	21	100.0	19	73.1	40	85.1
	Total	**21**	**100.0**	**26**	**100.0**	**47**	**100.0**

Greywater reuse systems

		City of Cape Town		City of Tshwane		Total	
		Count	%	Count	%	Count	%
Small/single parent (1-3 members)	Yes	21	52.5	6	15.4	27	34.2
	No	19	47.5	33	84.6	52	65.8
	Total	**40**	**100.0**	**39**	**100.0**	**79**	**100.0**
Average/nuclear (4 members)	Yes	14	48.3	3	13.6	17	33.3
	No	15	51.7	19	86.4	34	66.7
	Total	**29**	**100.0**	**22**	**100.0**	**51**	**100.0**
Extended (More than 4 members) and multiple families	Yes	13	61.9	8	30.8	21	44.7
	No	8	38.1	18	69.2	26	55.3
	Total	**21**	**100.0**	**26**	**100.0**	**47**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As Table 19 indicates, in total, the largest proportion of households that reported having taken up one or more of the selected WSUD measures at the time of the survey consisted of over four members (68.1%). This was followed by households that consisted of either one, two or three household members (55.7%) that reported to have done the same. The smallest proportion of households that reported the current uptake of selected WSUD measures consisted of strictly four members (51.0%). The same trend was reported for households in the City of Tshwane.

Similarly, for RWH, PP, and GWR systems, the largest proportions of households that reported to have taken up each of the three measures at the time of the survey, were also made up of over four household members (44.7% and 14.9% and 44.7%), respectively. The same trend was reported for households in the City of Tshwane. The differences in uptake between households with precisely four members and households with between one and three members are unstable; the minor differences in size between small and nuclear households could be a possible explanation for this occurrence.

However, the bulk of the results are consistent with the main contention raised in the literature and indicate the possible effect of a household's size on its uptake of selected WSUD measures. Nevertheless, results from the City of Cape Town, which are not consistent with the literature, may be reflective of the effect of day-zero, whereby selected WSUD measures were taken up by a large proportion of households, regardless of the number of household members.

4.2.3.3. Education

As informed by existing literature, highly educated – as opposed to relatively less-educated – individuals or household members are more likely to adopt pro-environmental behaviour, which is inclusive of the uptake of selected WSUD measures (Baiyegunhi, 2015). As such, Table 20 shows the results for the association between the current household uptake of selected WSUD measures and the highest level of education in the sampled households, by municipality.

Table 20: Association between household uptake of Water Sensitive Urban Design measures and highest level of education by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined		Count	%	Count	%	Count	%
No schooling or some schooling, or completed Grade 12	Yes	13	61.9	4	36.4	17	53.1
	No	8	38.1	7	63.6	15	46.9
	Total	**21**	**100.0**	**11**	**100.0**	**32**	**100.0**
Undergraduate or TVET/College	Yes	24	77.4	13	46.4	37	62.7
	No	7	22.6	15	53.6	22	37.3
	Total	**31**	**100.0**	**28**	**100.0**	**59**	**100.0**
Postgraduate	Yes	24	75.0	19	40.4	43	54.4
	No	8	25.0	28	59.6	36	45.6
	Total	**32**	**100.0**	**47**	**100.0**	**79**	**100.0**
Rainwater harvesting		**City of Cape Town**		**City of Tshwane**		**Total**	
		Count	%	Count	%	Count	%
No schooling or some schooling, or completed Grade 12	Yes	8	38.1	0	.0	8	25.0
	No	13	61.9	11	100.0	24	75.0
	Total	**21**	**100.0**	**11**	**100.0**	**32**	**100.0**
Undergraduate or TVET/College	Yes	18	58.1	7	25.0	25	42.4
	No	13	41.9	21	75.0	34	57.6
	Total	**31**	**100.0**	**28**	**100.0**	**59**	**100.0**
Postgraduate	Yes	18	56.2	11	23.4	29	36.7
	No	14	43.8	36	76.6	50	63.3
	Total	**32**	**100.0**	**47**	**100.0**	**79**	**100.0**
Permeable paving		**City of Cape Town**		**City of Tshwane**		**Total**	
		Count	%	Count	%	Count	%
No schooling or some schooling, or completed Grade 12	Yes	0	.0	3	27.3	3	9.4
	No	21	100.0	8	72.7	29	90.6
	Total	**21**	**100.0**	**11**	**100.0**	**32**	**100.0**
Undergraduate or TVET/College	Yes	1	3.2	6	21.4	7	11.9
	No	30	96.8	22	78.6	52	88.1
	Total	**31**	**100.0**	**28**	**100.0**	**59**	**100.0**
Postgraduate	Yes	3	9.4	8	17.0	11	13.9
	No	29	90.6	39	83.0	68	86.1
	Total	**32**	**100.0**	**47**	**100.0**	**79**	**100.0**
Greywater reuse systems		**City of Cape Town**		**City of Tshwane**		**Total**	
		Count	%	Count	%	Count	%
No schooling or some schooling, or completed Grade 12	Yes	10	47.6	1	9.1	11	34.4
	No	11	52.4	10	90.9	21	65.6
	Total	**21**	**100.0**	**11**	**100.0**	**32**	**100.0**
Undergraduate or TVET/College	Yes	17	54.8	8	28.6	25	42.4
	No	14	45.2	20	71.4	34	57.6
	Total	**31**	**100.0**	**28**	**100.0**	**59**	**100.0**
Postgraduate	Yes	18	56.3	7	14.9	25	31.6
	No	14	43.7	40	85.1	54	68.4
	Total	**32**	**100.0**	**47**	**100.0**	**79**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As Table 20 indicates, in total, the largest proportion of households that reported to have taken up at least one of the selected WSUD measures at the time of the survey had at least one household member with either an undergraduate degree or technical qualification, i.e. TVET, (62.7%). This was followed by households that had at least one member with a postgraduate qualification (54.4%), i.e. at the time the survey was conducted. The smallest proportion of households that reported to have taken up either one or more of the selected WSUD measures reported to have had no household members with any form of tertiary qualification (53.1%). The same trend was observed for households in the Cities of Cape Town and Tshwane.

Similarly, for RWH, the two largest proportions of households that reported to have taken up RWH, i.e. in total, and at the time of the survey – had at least one household member with a tertiary qualification. The largest proportion of households that reported to have taken up RWH confirmed to have had at least one household member with either an undergraduate degree or a technical qualification, i.e. TVET (42.4%), while the second-largest proportion of households that reported to have taken up RWH had at least one household member with a postgraduate qualification (36.7%). The same trend was observed for households in the Cities of Cape Town and Tshwane.

With regards to the current household uptake of PP and GWR systems, in total, the largest proportion of households that reported to have taken up PP and GWR systems also reported to have had at least one household member with either an undergraduate degree or a technical qualification, i.e. TVET (13.9% and 42.4%). This was followed by households that confirmed to have had at least one member with a postgraduate qualification, i.e. with regards to the uptake of PP (11.9%); and households that indicated to have not had any household member(s) with a tertiary qualification – i.e. whereby household members either had no schooling or some form of basic education – for GWR systems (43.4%). The same trend for PP uptake was observed for households in the City of Cape Town, while the two largest proportions of households that reported to have taken up GWR systems across the Cities of Cape Town and Tshwane, had at least one household member with a tertiary qualification.

Therefore, in general, the household uptake of WSUD measures is noticeably higher in households with members that have some form of tertiary qualification. This is consistent with the findings in the literature. However, there are no consistent differences in uptake between households with at least one member with either an undergraduate degree or TVET and households with at least one member with a postgraduate qualification. Similar findings were observed for households across the Cities of Tshwane and Cape Town. In such cases, an examination into the statistical significance of the level of education, as a factor, might help determine its effectiveness as a possible predictor of the household uptake of selected WSUD measures.

4.2.3.4. Age of the Head of the Household

With regards to the effect of age as a possible predictor of the household uptake of selected WSUD measures, the key premise in the literature is that in comparison to their younger counterparts, older water users, or household members, are more likely to adopt pro-environmental behaviour, which is inclusive of the uptake of selected WSUD measures (Schirmer & Dyer, 2018). Table 21 shows the results for the association between the current household uptake of selected WSUD measures and the age of the head of the household, by municipality.

Table 21: Association between household uptake of Water Sensitive Urban Design measures and age of head of household by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	**%**	**Count**	**%**	**Count**	**%**
44 Years or younger	Yes	10	66.7	3	23.1	13	46.4
	No	5	33.3	10	76.9	15	53.6
	Total	**15**	**100.0**	**13**	**100.0**	**28**	**100.0**
45 – 65 Years	Yes	27	69.2	22	44.0	49	55.1
	No	12	30.8	28	56.0	40	44.9
	Total	**39**	**100.0**	**50**	**100.0**	**89**	**100.0**
66 Years or older	Yes	23	85.2	7	38.9	30	66.7
	No	4	14.8	11	61.1	15	33.3
	Total	**27**	**100.0**	**18**	**100.0**	**45**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
44 Years or younger	Yes	9	60.0	3	23.1	12	42.9
	No	6	40.0	10	76.9	16	57.1
	Total	**15**	**100.0**	**13**	**100.0**	**28**	**100.0**
45 – 65 Years	Yes	18	46.2	9	18.0	27	30.0
	No	21	53.8	41	82.0	62	69.7
	Total	**39**	**100.0**	**50**	**100.0**	**89**	**100.0**
66 Years or older	**Yes**	17	63.0	6	33.3	23	51.1
	No	10	37.0	12	66.7	22	48.9
	Total	**27**	**100.0**	**18**	**100.0**	**45**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
44 Years or younger	Yes	1	6.7	2	15.4	3	10.7
	No	14	93.3	11	84.6	25	89.3
	Total	**15**	**100.0**	**13**	**100.0**	**28**	**100.0**
45 – 65 Years	Yes	2	5.1	10	20.0	12	13.5
	No	37	94.9	40	80.0	77	86.5
	Total	**39**	**100.0**	**50**	**100.0**	**89**	**100.0**
66 Years or older	Yes	1	3.	3	16.7	4	8.9
	No	26	96.3	15	83.3	41	91.1
	Total	**27**	**100.0**	**18**	**100.0**	**45**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
44 Years or younger	Yes	6	40.0	2	15.4	8	28.6
	No	9	60.0	11	84.6	20	71.4
	Total	**15**	**100.0**	**13**	**100.0**	**28**	**100.0**
45 – 65 Years	Yes	24	61.5	11	22.0	35	39.3
	No	15	38.5	39	78.0	54	60.7
	Total	**39**	**100.0**	**50**	**100.0**	**89**	**100.0**
66 Years or older	Yes	14	51.9	2	11.1	16	35.6
	No	13	48.1	16	88.9	29	64.4
	Total	**27**	**100.0**	**18**	**100.0**	**45**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake is indicated in the second column.

As indicated in Table 21, in total, the largest proportion of households that reported to have taken up one or more of the selected WSUD measures at the time of the survey had household heads that were at least 66 years of age or older (66.7%). This was followed by households with household heads that were between the ages of 45 and 65 years. The smallest proportion of households that reported the uptake of selected WSUD measures had household heads that were 44 years old or younger. The same trend was observed for households in the City of Cape Town and is consistent with the findings from the study by Schirmer and Dyer (2018).

Regarding the current household uptake of RWH, in total, the largest proportion of households that reported to have taken up RWH at the time of the survey had household heads that were 66 years of age older (51.1%). The same was reported for households in both the Cities of Cape Town and Tshwane, whereby the largest proportions of households (63.0% and 33.3%, respectively) that reported the current uptake of RWH also had household heads that were 66 years of age or older.

In terms of the rest of the measures, in total, the largest proportions of households that reported to have taken up PP and GWR systems at the time of the survey had household heads that were between the ages of 45 and 65 years (13.5% and 39.3%, respectively). The same trend for both measures was observed for households in the City of Tshwane. However, in total, the smallest proportion of households that reported the current uptake of PP (8.9%) had households heads that were 66 years of age or older. In comparison, the smallest proportion of households that reported the current uptake of GWR systems had household heads that were either 44 years in age or younger (28.6%).

Therefore, only results for the combined uptake of selected WSUD measures and RWH, are consistent with the key arguments, and findings, presented in the literature. However, results for the rest of the measures and across the relevant case areas were inconsistent with the literature. Moreover, because households headed by individuals who were either 44 years older or younger did not emerge as prevalent adoptees of selected WSUD measures; the results do not necessarily validate the key arguments by Zou et al. (2015), which link the adoption of pro-environment behaviour with younger water users, as a result of their progressive agenda (Zou et al., 2015).

Therefore, these varied findings do not provide any indication of the effectiveness of age, or rather the age of the head of household, as a possible predictor for the household uptake of selected WSUD measures. Furthermore, the findings present an incentive to investigate Garcia et al.'s (2015) position on the association between household members that are more likely to spend their time at home – including unemployed and retired individuals, and women, in some cases – as well as the relevant household's engagement in pro-environmental behaviour and the consequent uptake of selected WSUD measures. Alternatively, the association between the average (i.e. median or modal) age of household members and the relevant households uptake of selected WSUD measures – i.e. as opposed to the age of the head of the household – could be examined, which may yield more consistent results.

4.2.3.5. Ownership of Dwelling

As informed by the literature, households that own their homes are more likely to take up selected WSUD measures than those that do not (Pinto & Maheshwari, 2010; Owusu & Teye, 2015). As such, Table 22 shows the results for the association between the current household uptake of selected WSUD measures and the ownership status of the relevant households' dwellings, by municipality.

Table 22: Association between household uptake of Water Sensitive Urban Design measures and ownership status of dwelling by municipality (suburbs and satellite towns only)

		City of Cape Town		City of Tshwane		Total	
Combined							
		Count	**%**	**Count**	**%**	**Count**	**%**
Own	Yes	56	74.7	35	46.1	91	60.3
	No	19	25.3	41	53.9	60	39.7
	Total	**75**	**100.0**	**76**	**100.0**	**151**	**100.0**
Rent	Yes	5	50.0	2	20.0	7	35.0
	No	5	50.0	8	80.0	13	65.0
	Total	**10**	**100.0**	**10**	**100.0**	**20**	**100.0**
Rainwater harvesting							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Own	Yes	43	57.3	19	25.0	62	41.1
	No	32	42.7	57	75.0	89	58.9
	Total	**75**	**100.0**	**76**	**100.0**	**151**	**100.0**
Rent	Yes	3	30.0	0	.0	3	15.0
	No	7	70.0	10	100.0	17	85.0
	Total	**10**	**100.0**	**10**	**100.0**	**20**	**100.0**
Permeable paving							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Own	Yes	4	5.3	17	22.4	21	13.9
	No	71	94.7	59	77.6	130	86.1
	Total	**75**	**100.0**	**76**	**100.0**	**151**	**100.0**
Rent	Yes	0	.0	0	.0	0	.0
	No	10	100.0	10	100.0	20	100.0
	Total	**10**	**100.0**	**10**	**100.0**	**20**	**100.0**
Greywater reuse systems							
		City of Cape Town		**City of Tshwane**		**Total**	
		Count	**%**	**Count**	**%**	**Count**	**%**
Own	Yes	40	53.3	15	19.7	55	36.4
	No	35	46.7	61	80.3	96	63.6
	Total	**75**	**100.0**	**76**	**100.0**	**151**	**100.0**
Rent	Yes	5	50.0	2	20.0	7	35.0
	No	5	50.0	8	80.0	13	65.0
	Total	**10**	**100.0**	**10**	**100.0**	**20**	**100.0**

Notes: Households in suburbs/satellite towns only. Reported WSUD uptake indicated in the second column.

As indicated in Table 22, in total, a larger proportion of households (60.3%) that reported to have taken up one or more of the selected WSUD measures at the time of the survey owned their respective dwellings, while a relatively smaller proportion of households that also confirmed the current uptake of WSUD measures (35.0%) were renting. The same trend was observed for households in the Cities of Cape Town and Tshwane.

Regarding the household uptake of each of the three WSUD measures, in total, larger proportions of households (41.1%, 13.9% and 36.4%) that reported to have taken up RWH, PP, and GWR systems, respectively, owned their respective dwellings. These were followed by relatively smaller proportions of tenant households (15.0%, 0% and 35.0%) that also reported the current uptake of each of the three measures, i.e. respectively, at the time of the survey. The same trend was observed for households in the Cities of Cape Town and Tshwane, i.e. except for the uptake of GWR systems across households in the City of Tshwane. However, the differences in uptake, as outlined in Table 22, were not considerable.

Therefore, these results are consistent with those outlined in studies by Pinto and Maheshwari (2010) as well as Owusu and Teye (2015). Moreover, the results indicate the noticeable effect of a household's ownership status as a possible predictor for WSUD uptake.

4.2.4. Statistical Significance and Effect Sizes of Predictors of Household Uptake of Water Sensitive Urban Design Measures

This section discusses the statistical significance of the various possible predictors, as identified and discussed earlier. As such, Table 23 shows the predictors of the household uptake of selected WSUD measures in the suburbs and satellite towns, i.e. in terms of predictor effects. Table 23 first shows results from a log-linear analysis to determine any significant three-way effects (i.e. municipality × predictor × uptake), followed by Chi-square and Fisher's exact tests for significant differences between predictor categories, as well as the effect sizes for each predictor using Cramér's *V*. For each log-linear analysis, all expected counts were > 1 and 20%+ of expected counts were > 5. The likelihood ratio of each model was $\chi^2(0) = 0$, $p = 1$. Individual Chi-square tests are also based on the likelihood ratio considering small samples, whereas Fisher's exact test was used where expected counts < 5 (df = 1).

Table 23: Statistical significance and effect sizes of predictors of household uptake of Water Sensitive Urban Design measures **(Continued on next page)**

Predictor set	Predictor	Log-linear Analysis (Likelihood ratio)	City	Chi-Square Test (Likelihood ratio) Fisher's Exact Test	Cramér's *V*
Contextual / Physical	Source of water	$\chi^2(1, 180) = 0.269$, $p = 0.604$	Cape Town	N = 90; $p = 0.378$[b]	0.106
			Tshwane	$\chi^2(1, 90) = 0.202$, $p = 0.653$[a]	0.047
			Total	$\chi^2(1, 180) = 1.980$, $p = 0.159$[a]	0.106
	Size of stand	$\chi^2(1, 118) = 2.690$, $p = 0.101$	Cape Town	N = 53; $p = 0.298$[b]	0.183
			City of Tshwane	$\chi^2(1, 65) = 0.980$, $p = 0.322$[a]	0.122
			Total	$\chi^2(1, 118) = 2.283$, $p = 0.131$[a]	0.139
	Size of house	$\chi^2(1, 106) = 1.433$, $p = 0.231$	Cape Town	N = 47; $p = 1.000$[b]	0.040
			City of Tshwane	$\chi^2(1, 59) = 2.262$, $p = 0.133$[a]	0.190
			Total	$\chi^2(1, 106) = 0.672$, $p = 0.413$[a]	0.079
Behavioural / Situational	Existing water-saving behaviour	$\chi^2(2, 180) = 0.280$, $p = 0.861$	Cape Town	$\chi^2(2, 90) = 11.516$, $p = 0.003$[a]*	0.378*
			City of Tshwane	$\chi^2(2, 90) = 17.363$, $p < 0.001$[a]*	0.416*
			Total	$\chi^2(2, 180) = 31.464$, $p < 0.001$[a]*	0.413*
	Announcements of water restrictions	$\chi^2(1, 106) = 0.091$, $p = 0.763$	Cape Town	N = 71; $p = 0.463$[b]	0.099
			City of Tshwane	N = 35; $p = 0.238$[b]	0.201
			Total	$\chi^2(1, 106) = 2.733$, $p = 0.098$[a]	0.165
	Enforcements of water restrictions	$\chi^2(1, 105) = 0.057$, $p = 0.811$	Cape Town	$\chi^2(1, 71) = 0.004$, $p = 0.949$[a]	0.008
			City of Tshwane	N = 34; $p = 1.000$[b]	0.060
			Total	$\chi^2(1, 105) = 0.004$, $p = 0.950$[a]	0.006

Notes: a Chi-Square Test (Likelihood ratio); b Fisher's Exact Test; * Significant at the 0.05 level.

Table 23: Statistical significance and effect sizes of predictors of household uptake of Water Sensitive Urban Design measures (Continued from previous page)

Predictor set	Predictor	Log-linear Analysis (Likelihood ratio)	City	Chi-Square Test (Likelihood ratio) Fisher's Exact Test	Cramér's *V*
Socio-demographic	Income area	$\chi^2(2, 180) = 0.443$, $p = 0.801$	Cape Town	$\chi^2(2, 90) = 2.513$, $p = 0.285$[a]	0.174
			City of Tshwane	$\chi^2(2, 90) = 2.266$, $p = 0.322$[a]	0.158
			Total	$\chi^2(2, 180) = 13.567$, $p = 0.001$[a*]	0.274*
	Household size	$\chi^2(2, 177) = 4.415$, $p = 0.110$	Cape Town	$\chi^2(2, 90) = 0.680$, $p = 0.712$[a]	0.087
			City of Tshwane	$\chi^2(2, 87) = 9.037$, $p = 0.011$[a*]	0.322*
			Total	$\chi^2(2, 177) = 3.203$, $p = 0.202$[a]	0.133
	Highest level of education in household	$\chi^2(2, 170) = 0.228$, $p = 0.892$	Cape Town	$\chi^2(2, 84) = 1.600$, $p = 0.449$[a]	0.141
			City of Tshwane	$\chi^2(2, 86) = 0.416$, $p = 0.812$[a]	0.070
			Total	$\chi^2(2, 170) = 1.202$, $p = 0.548$[a]	0.084
	Age of head of household	$\chi^2(2, 162) = 2.177$, $p = 0.337$	Cape Town	$\chi^2(2, 81) = 2.817$, $p = 0.244$[a]	0.181
			City of Tshwane	$\chi^2(2, 81) = 2.000$, $p = 0.368$[a]	0.153
			Total	$\chi^2(2, 162) = 3.155$, $p = 0.207$[a]	0.139
	Ownership status	$\chi^2(1, 171) = 0.019$, $p = 0.890$	Cape Town	N = 85; $p = 0.137$[b]	0.177
			City of Tshwane	N = 86; $p = 0.177$[b]	0.169
			Total	$\chi^2(1, 171) = 4.570$, $p = 0.033$[a*]	0.164*

Notes: a Chi-Square Test (Likelihood ratio); b Fisher's Exact Test; * Significant at the 0.05 level.

As Table 23 illustrates, none of the log-linear analyses yielded any significant three-way effects across municipalities, predictor variables, and current uptake of WSUD measures, which means that there are no significant differences between the City of Cape Town and the City of Tshwane in terms of the effect any of the predictors had on the household uptake of each of the WSUD measures.

Therefore, although the current uptake of all three measures combined, as outlined in Table 11, is noticeably higher in the City of Cape Town's suburbs and satellite towns (73.3%) compared to suburbs and satellite towns in the City of Tshwane (41.1%), the effect of day-zero appears to be an immediate short-term response by households to drastic measures in the City Cape Town, rather than a contributor towards predictor effects that may lead to longer-term or more established levels of WSUD uptake. Therefore, drastic scenarios such as day-zero should probably not be seen as primary catalysts for households to take up WSUD measures. As such, municipal planning and assistance towards the household uptake of WSUD measures at the neighbourhood and household level are likely to remain important, especially in economically stressed settings.

With regards to predictors that had a significant effect on the household uptake of selected WSUD measures, *existing water-saving behaviour* $\chi^2(2, 180) = 31.464$, $p < 0.001$, *income area* $\chi^2(2, 87) = 9.037$, $p = 0.011$ and *ownership status* $\chi^2(1, 171) = 4.570$, $p = 0.033$ were revealed to be statistically significant across all sampled households, i.e. in the Cities of Cape Town and Tshwane combined. For households in the City of Tshwane, *existing water-saving behaviour* $\chi^2(2, 90) = 17.363$, $p < 0.001$ and *household size* $\chi^2(2, 87) = 9.037$, $p = 0.011$ emerged as statistically significant predictors; while *existing water-saving behaviour* $\chi^2(2, 90) = 11.516$, $p = 0.003$ also emerged as a significant predictor for households sampled across the City of Cape Town. With regards to effect sizes, *existing water-saving behaviour* had the strongest effect on the household uptake of selected WSUD measures (Cramér's $V = 0.413$; $p < 0.001$). This was followed by *income*, which had a weak to moderate effect on the household uptake (Cramér's $V = 0.274$; $p = 0.001$) and then *ownership* (Crammer's V = 0.164; $p = 0.032$), of which the effect thereof was weak.

Existing water-saving behaviour as a predictor of the household uptake of WSUD measures corresponds with other studies highlighting the self-enforcing nature of pro-environmental behaviour (Schirmer & Dyer, 2018; Amodeo & Francis, 2019). Moreover, while income appears to be a significant predictor of household uptake, as cited above, it had a weak to moderate effect on the uptake of selected WSUD measures (Cramér's $V = 0.274$; $p = 0.001$). Lastly, although the effect of ownership is weak (Cramér's $V = 0.164$; $p = 0.032$), as outlined earlier, a larger proportion of households that own their houses (60.3%) took up at least one of the selected WSUD measures as opposed to households that were renting (35%), i.e. at the time of the survey.

4.3 Perceived Effectiveness of Water Demand-side Management Instruments

As discussed earlier, municipal water DSM instruments refer to instruments that are developed and either taken up or implemented to reduce the amount of water that consumers use and demand (Wegelin & Jacobs, 2012; Dascher et al., 2014). Therefore, for the purpose of this study, municipal water DSM instruments refer to a group of instruments that are developed and either implemented or taken up to reduce the amount of municipal (i.e. portable and centralised) water that is typically consumed and demanded by urban households (Wegelin & Jacobs, 2012; Dascher et al., 2014). Municipal water DSM instruments consist of instruments that are related to the price of water (i.e. price DSM instruments) – which generally include rationing and increased block rates – and ones that are not related to the price of water (i.e. non-price DSM instruments) – which are typically inclusive of education campaigns on water and water conservation, water use restrictions, as well as subsidies for the installation of water-efficient technologies and the uptake of WSUD measures (Renwick & Green, 2000; Vernon & Tiwari, 2009; Fielding et al., 2012; Dascher et al., 2014).

However, for this particular study, the following municipal water DSM instruments comprised of the following:

- Assistance to implement water-saving measures
- Assistance to implement water sensitive design measures
- Tax incentives for reducing or limiting water use
- General water restrictions
- Fines for increasing use or using water above a certain quantity
- Water rate increases
- Naming and shaming of our neighbourhood for increasing use or using water above a certain quantity

Table 24 shows the perceived effectiveness of (and the inherent preference for) the above mentioned municipal water DSM instruments to reduce household use of municipal water.

Respondents were asked to rank each of the seven instruments illustrated in Table 24 from most effective (as indicated by the scale unit 1) to least effective (as indicated by the scale unit 7) in terms of causing their pertinent households to reduce municipal water use. After excluding cases with missing or duplicate rankings (i.e. responses that did not rank all the items from 1 to 7), rankings were grouped into three categories, i.e. 'most effective, (if ranked amongst the first three), 'neither effective nor ineffective' (if ranked fourth), and 'least effective (if ranked amongst the last three) instruments. Therefore, Table 24's percentages are for instruments ranked 'most effective', and instruments are sorted from largest to smallest total percentage (i.e. for the City of Cape Town and the City of Tshwane combined). Chi-square tests based on the likelihood ratio were conducted to test for significant differences between the Cities of Cape Town and Tshwane. All expected counts were either less than or equal to 0.9 and more than 20% of expected counts in each test were greater than five (df = 2).

Table 24: Perceived effectiveness of different municipal water demand-side management instruments by municipality (suburbs, satellite towns and townships). **(Continued on next page)**

Municipal water DSM instrument	Cape Town		City of Tshwane		Total		Significance
Suburb							
	Count	%	Count	%	Count	%	
Assistance to implement water-saving measures	25	56.8	44	77.2	69	68.3	*p* = 0.024*
Assistance to implement water sensitive design measures	27	61.4	36	63.2	63	62.4	*p* = 0.968
Tax incentives for reducing or limiting water use	24	54.5	34	59.6	58	57.4	*p* = 0.833
General water restrictions	23	52.3	24	42.1	47	46.5	*p* = 0.054
Fines for increasing use or using water above a certain quantity	13	29.5	17	29.8	30	29.7	*p* = 0.019*
Water rate increases	11	25.0	13	22.8	24	23.8	*p* = 0.599
Naming and shaming of our neighbourhood for increasing use or using water above a certain quantity	9	20.5	4	7.0	13	12.9	*p* = 0.124
Township							
Municipal water DSM instrument	**Cape Town**		**City of Tshwane**		**Total**		**Significance**
	Count	%	Count	%	Count	%	
Assistance to implement water-saving measures	15	78.9	17	73.9	32	76.2	*p* = 0.884
Assistance to implement water sensitive design measures	14	73.7	16	69.6	30	71.4	*p* = 0.953
Tax incentives for reducing or limiting water use	12	63.2	12	52.2	24	57.1	*p* = 0.444
General water restrictions	10	52.6	10	43.5	20	47.6	*p* = 0.425
Water rate increases	1	5.3	7	30.4	8	19.0	*p* = 0.090
Fines for increasing use or using water above a certain quantity	3	15.8	4	17.4	7	16.7	*p* = 0.976
Naming and shaming of our neighbourhood for increasing use or using water above a certain quantity	2	10.5	3	13.0	5	11.9	*p* = 0.729

*Notes: Municipal water DSM instruments are sorted from most to least preferred in terms of total responses across both cities; * Significant at the 0.05 level.*

Table 24: Perceived effectiveness of different municipal water demand-side management instruments by municipality (suburbs, satellite towns and townships). (Continued from previous page)

Total							
Municipal water DSM instrument	**Cape Town**		**City of Tshwane**		**Total**		**Significance**
	Count	**%**	**Count**	**%**	**Count**	**%**	
Assistance to implement water-saving measures	40	63.5	61	76.3	101	70.6	*p* = 0.059
Assistance to implement water sensitive design measures	41	65.1	52	65.0	93	65.0	*p* = 0.978
Tax incentives for reducing or limiting water use	36	57.1	46	57.5	82	57.3	*p* = 0.973
General water restrictions	33	52.4	34	42.5	67	46.9	*p* = 0.023*
Fines for increasing use or using water above a certain quantity	16	25.4	21	26.3	37	25.9	*p* = 0.062
Water rate increases	12	19.0	20	25.0	32	22.4	*p* = 0.472
Naming and shaming of our neighbourhood for increasing use or using water above a certain quantity	11	17.5	7	8.8	18	12.6	*p* = 0.299

*Notes: Municipal water DSM instruments are sorted from most to least preferred in terms of total responses across both cities; * Significant at the 0.05 level.*

As illustrated in Table 24 – in total, the largest proportion of households (70.6%) perceived *assistance to implement water-saving measures* (i.e. constant flow regulators, smart metering, and water-saving showerheads) as the most effective instrument to reduce their households' future municipal water use. This is followed by *assistance to implement WSD, or WSUD) measures* (i.e. RWH, GWR systems, PP) (65.0%) and *tax incentives for reducing or limiting water use* (57.3%), with no significant differences between the Cities of Cape Town and Tshwane. However, there is a significant difference (p = 0.0023) in the perceived effectiveness of *general water restrictions* between total households in the City of Cape Town and the City of Tshwane; and was ranked fourth, i.e. in total (46.9%).

Conversely, in total, *fines for increasing use or using water above a certain quantity*; *water rate increases*; as well as the *naming and shaming of our neighbourhood for increasing use or using water above a certain quantity* were perceived as least effective (25.9%, 22.4% and 12.6% of households). These findings thus indicate that households would prefer constructive rather than punitive instruments. The element of fear, which includes the fear of being held liable for one's water use behaviour and the fear of incurring additional water costs – could be a possible reason for this perception and inherent preference. Moreover, suppose fear is indeed an underlying factor influencing this preference. In that case, it might also indicate the underlying or concealed effectiveness of punitive measures in terms of causing, or rather forcing, households to reduce municipal water use. Therefore, punitive measures, or DSM instruments, may help ensure that municipal water DSM instruments are taken up or implemented. However, the sustainable uptake or implementation thereof is not necessarily guaranteed. For instance, regarding the maintenance of RWH systems, Mukheibir et al. (2014) note the following:

> "(The) literature (on rainwater tank maintenance activities) also suggests that voluntary rainwater tank owners are more motivated and hence more likely to maintain their system than those who have been forced to install one because of regulations" (Mukheibir et al., 2014, p. 382)

Nonetheless, and as highlighted earlier, a significantly larger proportion of households in the City of Cape Town (52.4%), however, perceived general water restrictions – which impose certain limitations on the use of water by households – to be more effective compared to those in the City of Tshwane (42.5%); highlighting the role of water use restrictions as part of efforts introduced to avoid day-zero.

Furthermore, the three instruments ranked most effective in total (i.e. *assistance to implement water-saving measures*; *assistance to implement water sensitive design measures* and *tax incentives for reducing or limiting water use*) were also ranked as such across suburbs (68.3%, 62.4% and 57.4%) and townships (76.2%, 71.4%, and 57.1%). Although *assistance to implement water sensitive design (WSUD) measures* was ranked as most effective by the second-largest proportion of households in total, most of the sampled suburban (and satellite town) households in the City Cape Town (61.4%) perceived the instrument as most effective. Many of these suburban and satellite town households in the City of Cape Town may have already implemented several water-saving measures in response to the then imminent day-zero. As a result, they may have recognised the uptake of WSUD measures as not only the next step towards the better use of water but also a necessary one. Moreover, in total, township households showed a stronger preference for water saving (76.2%) and WSUD (71.4%) measures as effective municipal water DSM instruments compared to those in suburbs and satellite towns (68.3% and 62.4%, respectively). The word 'assistance' may have motivated their perceptions and inherent preferences; and in such a case, it may be beneficial to investigate what various types of households regard as 'assistance'.

4.4. Summary: Findings and Discussion

The results, therefore, suggest detectable levels of uptake of selected WSUD measures amongst urban households in free-standing properties, particularly RWH and GWR systems, or at least manual GWR. The level of uptake highlights the importance of considering user acceptance and the factors influencing user acceptance in the planning and implementation of WSUD in a South Africa context. Moreover, a then imminent day-zero appears to have had an effect given the differences in the uptake of the measures between the Cities of Cape Town and Tshwane. However, uptake is mostly limited to suburbs, thus suggesting that WSUD in a South African household context is, among other things, driven strongly by settlement type as well as the factors or characteristics associated with each, particularly those of suburbs. Therefore, this indicates that WSUD should be tailored differently to areas experiencing different water stress levels as well as settlement types with different socio-economic conditions.

With regards to the second research objective, a total of 11 possible predictors or factors that have been found to influence the uptake of selected WSUD measures, i.e. in the existing body of knowledge – were examined for the purpose of this study. As a result, the existing use of water-saving measures – particularly the *number of water-saving measures* that were used by households at the time of the survey, *income area* as well as households' home-*ownership* status, emerged as statistically significant predictors of the household uptake of selected WSUD measures. However, contrary to the findings in the literature, the rest of the factors, or possible predictors of household WSUD uptake – did not emerge as statistically significant. This thus provides insight into the factors or characteristics that key stakeholders such as municipalities and water authorities could exploit or target in an effort to promote or encourage the uptake of WSUD measures by urban households. Notably, although proximity to water challenges did not emerge as a significant predictor of household WSUD uptake – i.e. as determined by the outcome of the log-linear analyses, which yielded no significant three-way effects across municipalities, predictor variables, and current uptake – it appears to have had a noticeable effect on the urban household uptake of selected WSUD measures, as indicated by the considerable uptake of selected WSUD measures by households across the City of Cape Town, which was characterised by water shortages at the time of the survey, i.e. day-zero.

In terms of the effect of each of the identified factors on the household uptake of selected WSUD measures, a majority of the factors, particularly the effects thereof – including the *number of water-saving measures*, and to some extent, *income*, *education*, *age* and *ownership* status – were consistent with the relevant hypotheses raised in the literature; while the effect of several other factors – including a household's *source of water for drinking and preparing food*, as well as the *size of stand* and *size of the house* – were not. However, the effects of the rest of the factors – including both the *announcement and enforcement of general water use restrictions* and *household size* – were somewhat consistent with the hypotheses raised in the literature, although these did not emerge as significant predictors. This further provides stakeholders with exemplary cases to target in an effort to promote the household uptake of WSUD measures.

With regards to the third research objective, as outlined earlier, *assistance to implement water-saving measures* – which include constant flow regulators, smart metering, water-saving showerheads – and *assistance to implement WSD, or WSUD measures* – including RWH, GWR systems, PP – were perceived as the most effective municipal water DSM instruments to reduce household water use by the two largest proportions of the sampled households. Furthermore, *fines for increasing use or using water above a certain quantity*; *water rate increases*; as well as *the naming and shaming of our neighbourhood for increasing use or using water above a certain quantity* were perceived as the most effective municipal water DSM instruments by the least proportions of households; indicating households' preference for constructive, rather than punitive, DSM instruments. Therefore, exploring the preferred types of water-saving measures and WSUD measures, as well as what households regard as municipal 'assistance', would be informative to stakeholders.

As such, the findings discussed in this chapter, along with their implications, were employed to help inform indicative recommendations policy and planning practice, as well as several proposed directions for further research. These are discussed in the subsequent chapter, i.e. Chapter 5, also referred to as the *recommendations for policy, planning practice and directions for further research* chapter.

CHAPTER 5: RECOMMENDATIONS FOR POLICY, PLANNING PRACTICE AND DIRECTIONS FOR FURTHER RESEARCH

As highlighted in the literature review (i.e. Chapter 2), several gaps in the existing body of knowledge on household uptake of Water Sensitive Urban Design (WSUD) measures were identified. For instance, literature on the factors influencing the household uptake of the various forms of permeable paving (PP) is limited. Furthermore, African case studies on household uptake of selected WSUD measures – including rainwater harvesting (RWH), PP and greywater (GWR), as well as WSUD in general, and studies that identify WSUD measures as a possible form of municipal water demand-side management (DSM) instrument – are also limited.

Although this study has made attempts to address each of these gaps by (1) examining the *physical and contextual*, *situational and behavioural* and *socio-demographic* factors that have been found in the literature to have an influence on the household uptake of PP, i.e. in addition to RWH and GWR; (2) examining households across two South African case areas, including the City of Cape Town and the City of Tshwane; and (3) by examining households' preferences for (i.e. through their perceived effectiveness of) *assistance to 'implement water sensitive design measures'* relative to other conventional municipal water DSM instruments – several other ways to take research on the household uptake of WSUD measures, i.e. at least in a South African context, further – are outlined in this particular chapter. Moreover, in addition to these directions for further research, the recommendations for policy – which are particularly relevant for stakeholders and decisionmakers in the fields of water resource management as well as urban, or settlement, planning and design – and recommendations for planning practice, are also provided for in this particular chapter. As outlined in Chapter 3, the use and audience of this research was identified as basic, with aspects of applied research. As such, indicative recommendations for policy and planning practice are identified in an effort to offer practical solutions to current challenges of water scarcity and insecurity – as applied research essentially aims to address concrete problems, while recommendations, or rather directions, for further research highlight how further studies can further contribute towards the advancement of fundamental knowledge on WSUD. The recommendations have been informed by findings from the literature, as well as results from this particular study, and are as such provided for in this particular chapter. These are outlined in the sections below.

5.1 Recommendations for Policy

This section outlines the policy recommendations that are aimed at promoting the household uptake of WSUD measures. As outlined in Chapter 4, the key findings revealed that households with existing pro-environmental behaviour, and those situated in middle to high (and high) income areas, as well as those that reside in homes or dwellings they own – are more likely to take up selected WSUD measures. Therefore, these results can be used to help inform the development of various institutional mechanisms, including policies, aimed at promoting the household uptake of WSUD measures.

For instance, with a particular focus on households, planners (as well as stakeholders from related disciplines) can design mechanisms that prioritise uptake in households that project or possess the above characteristics – as chances of uptake will likely be higher in such households. Furthermore, considering the water status (and use) of an area in which a household is situated, as well as various other physical factors such as a household's catchment area (m^2), as well as its supplementary water source generation and storage capacity (that's if such characteristics are confirmed as significant by other and/or future studies) – may provide the relevant policy makers with additional household characteristics to target or focus on when designing the relevant mechanisms.

As such, several recommendations for policy are presented below and these are particularly relevant for stakeholders and decisionmakers in the fields of water resource management as well as urban, or settlement, planning and design. Moreover, as informed by the study's research aim and purpose – which sought to compare the household uptake of selected WSUD measures across the City of Cape Town, an area characterised by severe water shortages at the time of the survey, with the household uptake of the same measures across the City of Tshwane, which is a less-water scarce area, at least at the time of the survey – as well as the consequent findings of this particular study – which reveavled a more pronounced uptake of WSUD measures in the City of Cape Town, i.e. a water scarce area – it is recommened that WSUD be tailored differently to areas experiencing different levels of water availability (or shortage) and to settlement types with different socio-economic conditions. This is recommended in an effort to yield optimum results when it comes to implementing WSUD in a South African context. As such, the recommendations for policy are discussed according to an area's water status, i.e. availability and shortage. The recommendations for each area are outlined in detail below.

5.1.1 Policy Recommendations for Households Facing Water Shortages, or Households in Water-scarce Areas

Although punitive measures were less preferred, or rather perceived as less effective, in relation to constructive measures or instruments such as *assistance to implement water sensitive design measures* – in areas characterised by severe water shortages, it may be necessary to disregard household preferences and perceptions in an effort to mitigate the negative impact of severe water shortages. Therefore, drastic measures such as the implementation and enforcement of legislative mandates and punitive instruments may be necessary. However, as Mukheibir et al. (2014) highlighted, the mandatory uptake of such measures can not ensure their maintenance by the relevant households, thus indicating the short-term and immediate effect of such an intervention. However, because severe water shortages are rarely permanent, such stringent interventions may be suitable to implement in such scenarios. Moreover, educational campaigns on the function, lifespan and maintenance aspects of the various measures could contribute to the long-term uptake of selected WSUD measures.

With regards to punitive instruments, tariff increases may be effective in compelling households to reduce their respective water use and take up selected WSUD measures, particularly RWH and GWR, in an effort to offset demand. However, as noted by Renwick and Green (2000); Inman and Jeffrey (2006); as well as Dascher et al. (2014), outdoor water use is likely more responsive to price DSM instruments, which are inclusive of tariff hikes, as well as general water use restrictions. Furthermore, households are more responsive to these instruments in summer. This, therefore, provides insight on when to implement and enforce such actions for maximum effect. However, with regards to high income households, particularly those that feel like they can always pay for water, regardless of the tariffs – legislative mandates in the form of by-laws, development controls and building codes – can be imposed on new developments to ensure compliance and realise the uptake of the relevant WSUD measures.

For instance, in their report titled G*uidelines on Compiling Water-sensitive Spatial Plans*, Fourie, et al. (2020) propose new building controls in an effort to promote the uptake of selected WSUD measures. These include development controls related to coverage, as well as the permeability of a proposed residential development's outdoor surface area:

> "The coverage element of building control[s] determines the percentage of a property that can be developed (e.g. 60% of residential buildings). The building footprint relates to the runoff in the sense that the arger the

> footprint, the larger the runoff volume generated. WSP [Water Sensitive Planning, or Water-sensitive Planning] calls for using rainwater [or stormwater] instead of allowing this to dissapate as runoff. The coverage building control can be leveraged in new buildings to achieve this. The developer of a new building can be incentivised by making a portion of the a property coverage conditional to the [uptake or installation of a RWH]." (Fourie, et al., 2020, p. 124)

With reference to existing development controls for developments zoned residential 3 in Limpopo's Lephalale local municipality, Fourie, et al. (2020) make further proposals. For instance, because existing development controls in Lephalale allow for some 80% of a residential 3 property to be developed, Fourie, et al. (2020) propose a reduced coverage of 70% with no installation of a RWH system and a coverage of 82% with the proposed installation of a RWH system (or technique) that is capable of storing and allowing for the reuse of at least 30% of rain, or storm water runoff (Fourie, et al., 2020).

Moreover, in terms of permeability, Fourie, et al. (2020) propose a requirement of PP as a compulsory development control for new, or greenfield, developments. Recharging groundwater tables, controlling stormwater runoff and offsetting costs for grey stormwater infrastructure are some of the benefits associated with this particular proposal (Fourie, et al., 2020). However, authorities must be careful not to promote the uptake of permeable surfaces that require significant amounts of water for irrigation (i.e. lawns). This is particularly relevant for contexts characterized by water shortages. Therefore, a response to such a dilemma, as proposed by Gober, et al. (2013), would be to impose size limitations on outdoor surface areas with alien and water-intensive vegetation (i.e.lawns), in an effort to curb the demand for municipal water for irrigation purposes (Gober, et al., 2013). These limitations could be specified as part of the by-laws.

Awareness building efforts and education campaigns on suitable and water efficient permeable outdoor surfaces may be necessary to promote user acceptance and ensure compliance. Moreover, landscape architects, in particular, may contribute towards awareness building efforts by providing homeowners, or household consumers, with and informing them about a variety of available permeable paving options when appointed to design household gardens or commissioned to execute landscaping.

New building codes that outline the compulsory uptake or installation of alternative, and decentralised, water supply systems such as groundwater abstraction points (GAP), RWH and GWR systems, that are able to produce a specified percentage of water (e.g. 30%) to offset potable water demands in new developments – constitutes another policy recommendations. This would be be similar to the United Kingdom's (UK's) national policy that requires the inclusion of energy saving measures and offsets such as solar panels in all new homes (The Renewable Energy Hub, 2018). In addition to reducing household demand for municipal or potable water, the uptake of such measures would also provide the relevant households with the ability to remain resilient during periods of drought and severe water shortages.

The introduction and enforcement of general water use restrictions, as informed by the City of Cape Town's exemplary day-zero scenario, also appears to be an effective coping mechanism for areas characterised by water scarcity. Moreover, although for this particular study, general water use restrictions did not emerge as significant predictors of the household uptake of selected WSUD measures, these (in the form of imposed limitations on the use of municipal or other centralised potable water supplies) were found to have a noticeable influence on the household uptake of RWH and GWR systems (Pinto & Maheshwari, 2010; Campisano et al., 2017; Institute for Security Studies, 2018). Hence providing additional insight into the various types of policy interventions that authorities can implement during periods of severe water scarcity.

5.1.2 Policy Recommendations for Households In Water Secure, or Less Water-Scarce, Areas

For households situated in water-secure or less water-scarce areas, one approach would be to make attempts towards realising the long-term and established household uptake of selected WSUD measure, and as informed by the literature, awareness building is an effective way to achieve this (Noiseux & Hostetler, 2010; Fewkes, 2012; Barthwal et al., 2014; Cote & Wolfe, 2014; Hayden et al., 2015; Charalambous et al., 2018; Schirmer & Dyer, 2018; O'Donnell et al., 2020). As such, education campaigns on water conservation, WSUD and WSUD measures; as well as the provision of subsidies and financial incentives for taking up the measures in question; as well as the administration of household surveys and the conducting of research studies on water, such as this one, can be used to engage households, and other water users alike, and as a result, build awareness (Charalambous et al., 2018).

Furthermore, it would be beneficial for stakeholders, particularly municipalities and water authorities, to introduce and provide financial incentives to keen and 'qualifying' households in an effort to promote the household uptake of WSUD measures, particularly RWH and GWR. As resonated by Fisher-Jeffes, et al. (2017), the installation of RWH and GWR systems should be encouraged and prioritised in areas where water is used as diversely and intensively as possible, which is usually the case for households in suburban areas. However, studies on the actual water use of households situated in different settlement types would be necessary to confirm this assumption and thus validate the recommendation by ensuring that incentives are provided to water-intensive households to ultimately reduce their demand and use of municipal water.

Moreover, as opposed to towships, which are typically characterised by low to middle-income households, suburban areas commonly accommodate middle to high-income households that can, in turn, afford to take up selected WSUD measures. This way, water service providers or other relevant stakeholders can cover a portion of the uptake or system installation costs instead of the full amount, which households in low income areas would likely require. This would be ideal for the South African context – whereby not all municipalities have the relevant spending money (i.e. for incentives and subsidies) at their disposal. In terms of establishing a selection criteria for ‘qualifying’ or eligible households, as informed by the results from this particular study, households residing in homes that they own (i.e. non-tenant households) could be prioritised over their counterparts (i.e.tenant households) – this would ensure the efficient use of limited municipal, or stakeholder, budgets for incentives.

Similarly, although households in informal settlements did not constitute any of the households sampled for this particular study due to their lack of basic water infrastructure and access to municipal or other centralised potable water services – it may be beneficial to promote and facilitate the uptake of RWH and GWR through various support mechanisms, including financial incentives and subsidies, in the interim. Moreover, the use of the measures in question may well be continued even after access to municipal and potable water services is acquired, all in an effort to generate supplementary sources of water for the relevant households, and to keep demand for potable water curbed; this would then be similar to what Armitage, et al. (2014) refer to as *leapfrogging*.

It may also be beneficial to improve the aesthetical design of the systems and technologies associated with selected WSUD measures (i.e. rainwater tanks, RWH systems, GWR systems and PP) in an effort to spur household interest when it comes to taking up the measures domestically. As highlighted by Hayden et al. (2015):

> "…it is crucial to recognise the role that aesthetic preferences play in homeowner willingness to adopt BMP [Best Management Practices; which are. inclusive of certain WSUD measures] and how important aesthetics are relative to other factors such as water conservation…" (Hayden et al., 2015, p. 2)

One way to do this could be through the adoption of general WSUD-technolgogy design standards for every designer and manufacturer to adhere to. However, the development of such standards would need to involve households as such technologies and measures would require their buy-in; this would also contribute towards establishing and ensuring user acceptance with regards to the measures. However, as highlighted by Dzidic and Green (2012), Gober, et al. (2013) as well as Hayden, et al. (2015), and using PP as an example – water users and households would first need to reform their perceptions of what consitutes an ideal garden. Aternatively, drastic improvements of the aesthetical aspects of the various measures could contribute towards the transformation of social norms and cultural preferences that favour more *green*, or water sensitive and sustainable alternatives, which are inclusive of the uptake of WSUD measures (Dzidic & Green, 2012; Hayden et al., 2015).

5.2 Recommendations for Planning Practice

In addition to making contributions towards the development of various policy mechanisms and other legislative mandates, several practical ways in which planners can help achieve the realisation of Water Sensitive Cities (WSCs), i.e. through the implementation of WSUD, are discussed in this section. For instance, Carmon and Shamir (2010) identify some land use planning and management practices that can be used to achieve one of the key objectives of WSUD, which is to respectively control and protect the quantity and quality of stormwater (Carmon & Shamir, 2010). Making provisions for more higher density residential developments, as well as mixed use developments – were identified as common land use practices that can contribute towards the realisation of WSCs.

In terms of higher density developments, Carmon and Shamir (2010) argue that in addition to various socio-economic benefits such as the such as reduced living costs and increased access to more and better services, high density developments have the potential to lower the volume of stromwater runoff and the pollution loads that are typically found in stormwater (Carmon & Shamir, 2010). To illustrate, findings from a study on the impact of densities on the generation of stormwater runoff revealed that "low density generates three times more runoff than the medium density and 3.8 times more than the higher density" (Carmon & Shamir, 2010, p. 184).

For mixed use developments, it is argued that the integration of a variety of land uses such as housing (i.e. residential), employment (i.e. business and commercial) and services (i.e. institutional, transport, etc.) reduces the extent of impervious areas such as roads, parking lots and sidewalks – which are commonly found in urban areas. Therefore, by placing a diverse range of urban activities and opportunities in close proximity would reduce the building footprint, together with its impervious surfaces (Carmon & Shamir, 2010).

The subsequent section outlines several possible directions for further research directions, which as discussed earlier, highlight how additional studies can further contribute towards the advancement of fundamental knowledge on WSUD.

5.3 Directions for Further Research

As discussed earlier, African literature on household uptake of WSUD measures and WSUD in general, is limited. As such, considering the limitations to this study and the limitations imposed by the scope of the study, as well as the findings of the study – four possible directions for more systematic research on the household uptake of WSUD are proposed. This are outlined in Table 25, which shows the possible directions for further research on the household uptake of WSUD. The directions are presented in terms of their relevant research design considerations, as informed by Du Toit and Mouton's (2013) typology of designs for social research. The design considerations include the underlying theoretical and/or analytical framework, the mode of reasoning behind each direction, the research purpose, methodological paradigm, methodological approach, research design, as well as the key research question (Du Toit & Mouton, 2013).

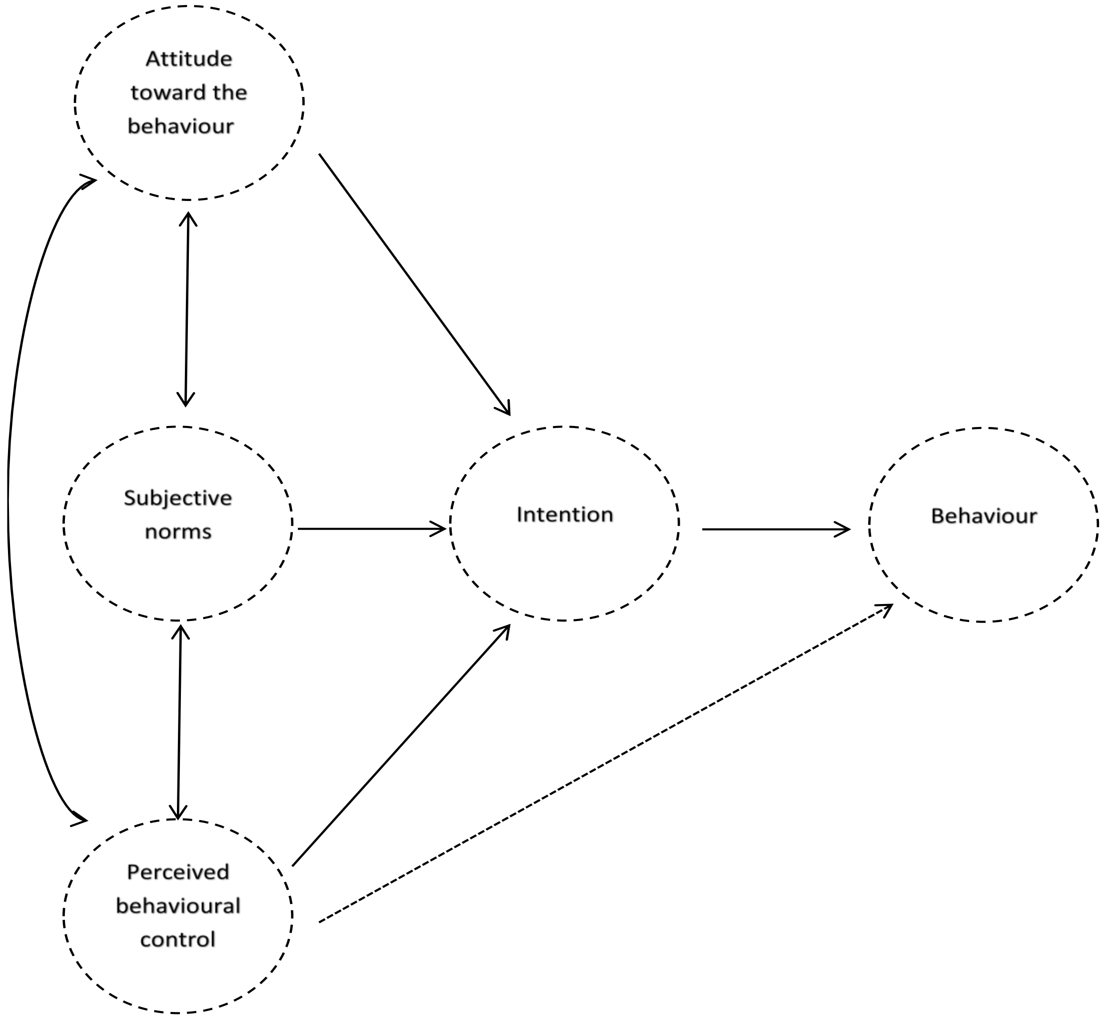
Table 25: Possible directions for further research on household uptake of Water Sensitive Urban Design measures

Considerations	**Direction**			
	1	**2**	**3**	**4**
Theoretical framework	Theory of Planned Behaviour (TPB)	Values, Awareness, Identity, Lifestyle (VAIL)	*	*
Mode of reasoning	Deductive (theory testing)	Deductive (theory testing)	Inductive (theory generating)	Inductive (theory generating)
Research purpose	Descriptive, explanatory	Descriptive, explanatory	Exploring household preferences for various municipal incentives towards WSUD as a municipal water demand-side management instrument, formulating practical planning and design recommendations	Exploring exemplary cases of uptake, i.e., where households used innovative ways to implement WSUD, and formulating practical planning and design recommendations
Methodological paradigm	Post-positivist	Post-positivist	Pragmatist	Critical realist / Pragmatist
Methodological approach	Quantitative	Quantitative	Qualitative, mixed	Qualitative
Research design (core logic)	Survey (generalisation)	Survey (generalisation)	Field Research / (Interpretation)	Case study (contextualisation) / Grounded theory (induction)
Key research question	*What is the effect of control factors (e.g., physical factors) relative to awareness, attitudinal and normative factors on household uptake of WSUD, and what are the possible implications for WSUD?*	*What is the relative effect of value, awareness, identity, and lifestyle factors on household uptake of WSUD, and what are the possible implications for WSUD?*	*What type of municipal assistance would different types of households prefer towards WSUD uptake?*	*What unique combinations of factors appear to contribute to exemplary cases of household uptake of WSUD within a given context, and how can planners and designers better enable WSUD at household level within that context?*

5.3.1 Direction 1

As outlined in Table 25, four possible directions for further research are proposed. The first recommended direction for further research, involves the application of the Theory of Planned Behaviour (TPB), which is a theoretical framework that is designed to predict and explain (i.e. inform) the behaviour of humans in specific contexts – which in this case would involve the prediction and explanation of pro-environmental behaviour; particularly the uptake of selected WSUD measures, by urban households and water users alike (Ajzen, 1991). Figure 8 outlines the theoretical process of the TPB, as originally developed by Ajzen (1991).

Figure 8: The Theory of planned behaviour

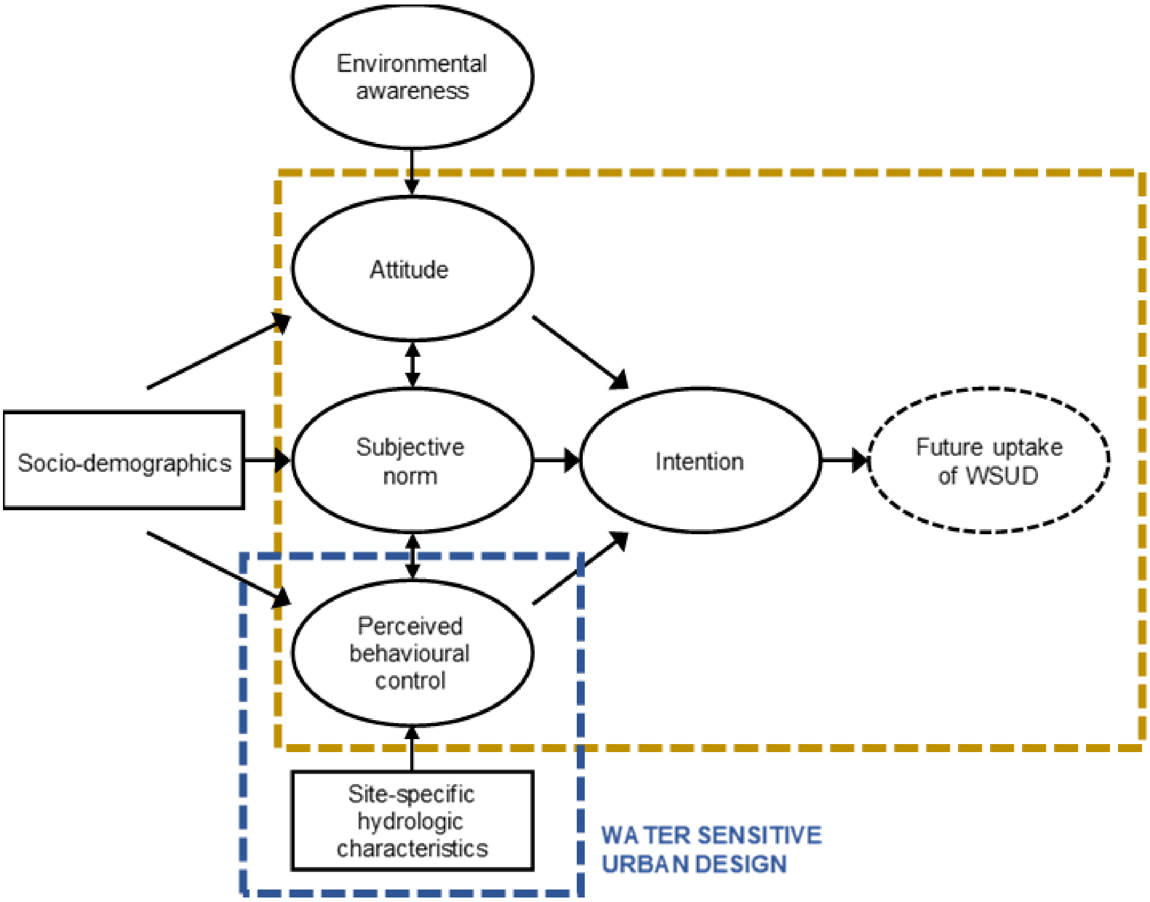


(Source: Ajzen, 1991)

As outlined in Figure 8, the TPB is a collection of various interconnected factors that have been identified as determinants of behaviour in a particular situation. The primary factors include a person's **attitude towards the particular behaviour**, **subjective norms** – which (similar to social norms) refer to an individual's ***beliefs*** about whether or not his or her peers, as well as those he or she considers as people of importance, think he or she should engage in a particular behaviour, as well as his or her **perceived behavioural control** (Ajzen, 1991). Perceived behavioural control refers to a person's perception of their ability to perform a particular behaviour, particularly their perception of the difficulty (or ease) of enacting the behaviour (Ajzen, 1991; Abrahamse, 2019). Moreover, this 'control' is influenced by various physical factors that shape a person's perceived ability to perform the behaviour. These include factors such as money, skills, time, and access to the necessary resources, amongst others. Therefore, the extent to which a person perceives themselves as having the right resources and prospects and the extent to which that person intends to perform the behaviour indicates the extent to which he or she will succeed in executing the behaviour (Ajzen, 1991).

As also outlined in Figure 8, all three factors are interconnected. Each of them exerts some influence on the others and on a person's **intention** to execute a particular behaviour. In terms of the TPB, an intention indicates the extent to which an individual is willing to try or the effort they are prepared to make, to perform a particular behaviour (Ajzen, 1991). Thus, as outlined in Figure 8, a person's intention to perform a behaviour and his or her perceived behavioural control directly influence his or her behaviour (Ajzen, 1991). As such, the first recommendation for further research first involves applying the TPB to this particular study. Figure 9 illustrates how the TPB can be applied to further research on WSUD.

Figure 9: Application of the Theory of Planned Behaviour



Note: Adapted from Ajzen (1991)

As illustrated in Figure 9, the application of the TPB to determine the household uptake of WSUD measures would involve examining the effect of various sets factors such as environmental awareness, a water user's attitude towards WSUD, subjective norms, and perceived behavioural control, on households', or water users', intentions to take up WSUD measures, as well as the effect thereof on actual uptake. As also illustrated in Figure 9, the latter three factors are, to some extent, influenced by various socio-demographic factors such as income, age and education – which play a significant role in the South African context, it is therefore important to consider their relative influence. Moreover, with regards to a water user's perceived behavioural control – physical factors (i.e. site-specific hydrological characteristics such as a household's installation, generation and storage capacity) and other WSP-related factors (i.e. policy mechanisms and legislative mandates) which have the ability to either facilitate or hinder the implementation of WSUD measures – may be conceptualised and operationalised as additional 'control' factors that inform a water user's perceived behavioural control.

The key research aim for this particular direction would be to determine the effect of various control factors, relative to other factors that may influence a water user's *intention* – including a water user's attitude towards WSUD , as well as factors related to the water user's, or household's, environmental awareness and subjective norms – on the household uptake of WSUD measures; and, consequently, identify the implications thereof with regards to household uptake of WSUD as well as planning for WSUD. Hence, similar to this particular study, a survey would constitute the proposed study's research design to include variables that measure and describe all the factors (and sets of factors) identified in the TPB, thus making it a quantitative, post-positivist study. Since this particular direction would entail the testing of an existing theory, i.e. TPB, the mode of reasoning would be deductive to describe and explain the effect of the relevant factors on households' uptake of WSUD measures, as well as their intentions to do so.

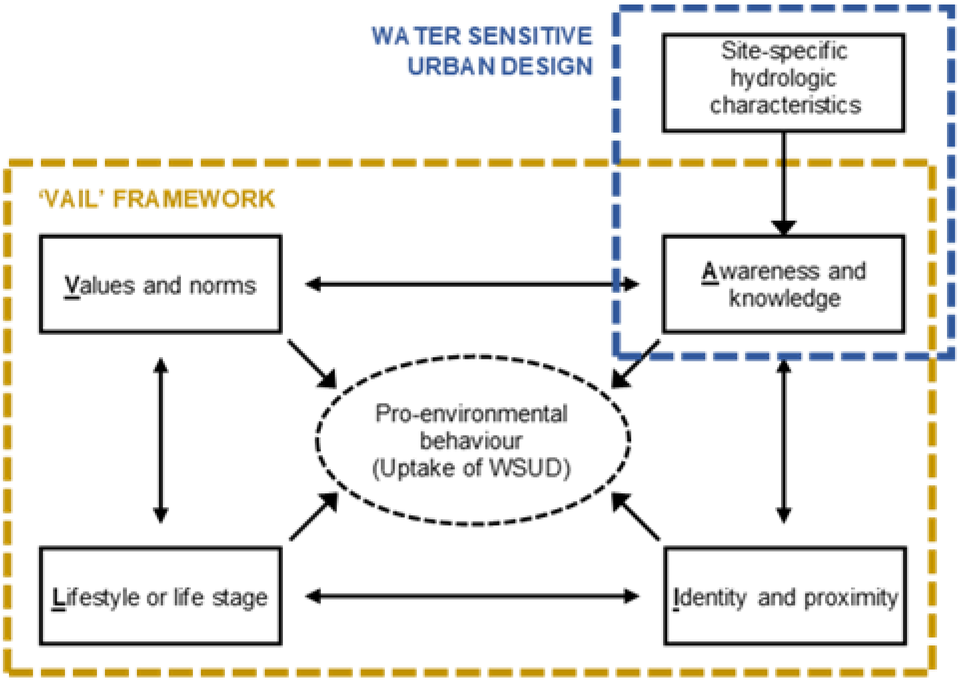
5.3.2 Direction 2

The second possible direction for further research involves Schirmer and Dyer's (2018) VAIL (i.e. Values and norms, Awareness, Identity and Lifestyle and life stage) framework. As outlined in Chapter 3, the influence of three sets of factors, including *physical and contextual*, *situational and behavioural* factors, and *socio-demographic* factors, on the household uptake of selected WSUD measures was identified as an analytical framework for this particular study. Similarly, as discussed in the literature review (Chapter 2), the Values and norms, Awareness, Identity and Lifestyle and life stage framework was designed by Schirmer and Dyer (2018) to identify and organise four domains, or sets, of factors that are likely to influence the adoption of WSUD-relevant pro-environmental behaviours (Schirmer & Dyer, 2018).

As identified earlier, social norms that are consistent with the protection of water resources were identified as factors under the set of 'value'; while a water user's awareness of an environmental problem, as well as their awareness about the actions that can either cause or address the relevant environmental problem, were identified as 'awareness' factors. A person's physical, cultural, aesthetic, economic, or social attachment to water resources was identified as part of the 'identity' set of factors, while socio-demographic characteristics such as age, home- ownership and gender were identified as part of the 'lifestyle and life stage' set (Schirmer & Dyer, 2018). Therefore, for this particular direction, one would have the option of adapting the variables measured by this particular study's survey instrument to the factors identified as part of the VAIL framework or alternatively designing a questionnaire that includes and accurately measures all the factors (i.e. variables) that are relevant for the VAIL framework.

As such, the main research objective of this direction would be to determine the relative effect of each of the set of factors identified as part of the VAIL framework – including value and norms, awareness, identity and lifestyle and life stage factors – on the household uptake of selected WSUD measures; and to identify the implications thereof for implementing WSUD in South Africa. Furthermore, similar to the application of the TPB to further research on the household uptake of WSUD, the VAIL framework could also be operationalised to incorporate physical factors that are relevant to the household uptake of WSUD, particularly site-specific hydrological properties (i.e. a household's installation, storage, maintenance and/or generation capacity), but also other factors such as settlement and dwelling type. Figure 10 illustrates how the VAIL framework can be applied to further research on WSUD.

Figure 10: Application of the Values, Awareness, Identity and Lifestyle framework



Note: Adapted from Schirmer and Dyer (2018).

This proposed direction to research could lead to a better understanding of how the various factors influence the ability of households to adopt WSUD measures, which may further lead to planners and designers being better able to facilitate WSUD at site or household level. Moreover, similar to the first proposed direction (i.e. TPB), a survey would constitute the proposed study's research design, with the intention of including variables that measure and describe the factors identified as part of the VAIL framework, thus making it a quantitative, post-positivist study. This direction's mode of reasoning would also be deductive, as it entails the testing, or application, of an existing analytical framework, which is the VAIL framework. The purpose of this proposed study would be to describe and explain the relative effect of value (and norms), awareness, identity and lifestyle (and life stage) on households' uptake of WSUD measures.

5.3.3 Direction 3

The third possible direction for further research involves an exploration into households' or water users' preferences; particularly their preferred type of municipal assistance, or rather incentive mechanisms, towards their uptake of WSUD measures.

As outlined in the findings chapter, '*assistance to implement water-saving measures'*, as well as '*assistance to implement water sensitive design measures'* were identified as the two most preferred municipal water DSM instruments (i.e. 70.6% and 65.0% respectively), i.e. relative to other conventional DSM instruments such as general water use restrictions and water rate increases. However, the word *'assistance'* was not elaborated nor itemised to provide respondents with '*assistance'* or incentive options from which to choose. As such, it would be beneficial to explore household preferences for, and understanding of, the various types or modes of incentives for taking up WSUD measures.

As informed by the existing body of knowledge, incentives can range from monetary incentives for installing the relevant measures, as well as the provision of the relevant water infrastructure or equipment such as rainwater tanks to subsidized labour for system installation and exemptions from equipment sales taxes (i.e. VAT) or stormwater taxes (which are currently not imposed on water users in South Africa) (Fewkes, 2012; Charalambous, et al., 2018). As such, options such as these could be itemised and described to respondents in an effort to acquire insight into their understanding and preference for each of them. Therefore, such a study would entail an exploration of household preferences for various municipal incentives towards the household uptake of WSUD measures as a DSM instrument. Such a study would thus contribute towards the formulation of relevant water sensitive planning and design recommendations for practice.

An appropriate research design for such a study would be field research, with a mixed approach to research. Moreover, research techniques such as survey questionnaires, i.e. to provide respondents with various incentive options to choose from, and Focus Group Discussions (FGDs), i.e. to validate the survey findings and to determine the underlying motivations behind the reported preferences, could be applied to gather data.

5.3.4 Direction 4

With regards to the fourth possible direction for further research, an exploration of unique combinations of factors that have been found to contribute to exemplary cases of household WSUD uptake within a given context, is proposed. This could provide stakeholders with exemplary cases, particularly households characteristics and conditions, to support, study, and understand in an effort to increase household uptake of WSUD measures. Such a study would entail case studies of dwellings or settings where households have found innovative ways to implement different WSUD measures, which is supplemented by a comprehensive description of the setting, or study context, along with its characteristics (i.e. the relevant factors). Therefore, such a study would provide an opportunity to understand and possibly forecast the unique combination of factors in a given context that seem to lead to the innovative implementation, or uptake of WSUD measures, by households.

Examples include – but are not limited to – factors such as gender, race, employment status, cultural background, as well as a water user's political affiliation or identity (e.g. progressives, conservatives or passivists). Several other physical factors, such as a household's catchment area, as well as generation (as determined by the catchment area, particularly for RWH), storage and installation capacity, would be of particular relevance to stakeholders in the field of planning and design.

As such, the purpose of such a study would be explorative, with an inductive mode of reasoning, as indicated by its ultimate objective of generating knowledge – which in this case would be a combination or combinations of factors that result in exemplary cases of the household uptake of WSUD measures. Moreover, this direction's approach to research would be qualitative, with a case study as a research design, i.e. as determined by its emphasis on standing exemplary cases of uptake in unique, or particular, contexts.

5.3.5 Summary: Directions for Further Research

As outlined above, four directions for further research on the household uptake of WSUD measures, at least in the South African context, have been identified. These include (1) the application of the TPB to help determine, or predict the household uptake of WSUD measures; (2) the use the VAIL framework to analyse the effect of value and norms, awareness, identity, as well as lifestyle and life stage factors on the household uptake of

WSUD measures; (3) exploring household preferences for various municipal incentives towards taking up WSUD measure(s) as a municipal water DSM instrument; as well as (4) an exploration of exemplary cases of the household uptake of WSUD measures in order to determine unique combinations of factors (i.e. predictors) that appear to contribute towards the ideal cases of household uptake of WSUD measures.

In addition to determining the household uptake of WSUD measures, the first possible direction for further research, along with the second one (i.e. the VAIL framework) could help determine fundamental predictors of the household uptake of WSUD measures – which stakeholders could harness and exploit in an effort to implement and proliferate the household uptake of selected WSUD measures at various scales. Furthermore, by exploring household preferences for incentives towards the household uptake of selected WSUD measures – the third direction could help inform the development of institutional mechanisms such as incentive and subsidization policies, that may be used to encourage the household uptake of selected WSUD measures. The incentives mechanisms would have a high chance of being effective as these would incorporate the element of user acceptance – as encapsulated through household or water user preferences for the various municipal incentives (Fewkes, 2012; Mukheibir, et al., 2014; Ahammed, 2017). In terms of the fourth possible direction for further research, which seeks to determine unique combinations of factors that appear to contribute to exemplary cases of the household uptake of WSUD measures within a given context – the applicability of the findings and consequent recommendations would be limited to the study's context. However, the study contexts would benefit from this study by, for instance, making attempts to understand and (where possible) support the combinations of factors that would be found to contribute to exemplary cases of household WSUD uptake, i.e. in an effort to proliferate the implementation of WSUD in the relevant context.

CHAPTER 6: CONCLUSION

6.1 Background of the Study Revisited

As noted in the introduction (Chapter 1), only 1% of the earth's fresh surface water is accessible to humans and other living species for consumption purposes. Moreover, in addition to the finite quantity of freshwater – numerous other factors, such as population growth, urbanisation, pollution, climate change and increasing water consumption per capita, also pose a threat to the availability and quality of freshwater; with the latter two factors particularly contributing to challenges of the availability of water in South Africa. For instance, the semi-arid climatic conditions found in most parts of the country, coupled with climate change, have accelerated drought conditions, leading to severe water shortages in areas such as the Karoo, Limpopo, and several southern parts of the country. In particular, residents of the City of Cape Town came close to experiencing what is commonly known as "day-zero" – representing a day in which 75% of the City's water reticulation system is turned off (Jacobs-Mata et al., 2018). This was a direct result of both drought conditions and excessive municipal water use, with households constituting the largest proportion of municipal water consumers (Sinclair-Smith & Winter, 2018). However, the City of Cape Town avoided a day-zero due to winter rains and the simultaneous application of numerous strategies, including the introduction and enforcement of municipal water use restrictions, to reduce demand (Gosling, 2019).

As such, and with populations expected to increase, exemplary cases of water shortages such as the City of Cape Town's have brought to attention the importance of exploring and implementing ways to manage, and possibly curb, the demand for potable water by urban households in order to cater for additional users and future inhabitants. One of the "ways" in which the demand for water can, and in some cases has been managed or curbed, is through the uptake of Water Sensitive Urban Design (WSUD) measures; which include rainwater harvesting (RWH), permeable paving (PP), and greywater reuse (GWR), i.e. amongst others.

Therefore, this particular study aimed to explore and describe urban households' uptake of selected WSUD measures across the Cities of Cape Town (i.e. an area characterised by water scarcity and severe water shortages, at least at the time the survey was conducted) and Tshwane (i.e. a less water-scarce area), as well as outline possible directions for further research and formulate indicative policy and planning recommendations for WSUD in a

South African context. In terms of the research objectives, the study sought to (1) determine households' past, present and future uptake of selected WSUD measures, including RWH, PP and GWR systems; (2) to examine the association between current uptake and three sets of factors that may influence uptake (which are also known as possible predictors); as well as (3) to determine households' preference for assistance to implement WSUD measures relative to other conventional municipal water DSM instruments. Moreover, and as noted earlier, the study emanated from a larger CSIR and UP (i.e. the University of Pretoria) collaborative research project on urban household water use behaviours. In particular, the project's survey instrument (APPENDIX 1), which included a set of questions on WSUD, was applied to this particular study.

6.2 Summary of Main Findings

Results indicate that almost half of survey respondents reported having taken up selected WSUD measures at the time of the study, i.e. *present* uptake (47.6%), and a year before then, i.e. *past* uptake (48.4%); this reported level of uptake highlights the importance of considering user acceptance, as reflected through household responses when it comes to the planning and implementation of WSUD in a South African context. The uptake of selected WSUD measures for both periods was most pronounced in the City of Cape Town, which may indicate the effect of day-zero, thus suggesting a need to tailor WSUD differently to areas experiencing varying water security levels. In this regard, various water-saving and WSUD measures ultimately appear to have a higher chance of being taken up in areas characterised by water scarcity and severe water shortages – a finding also confirmed in a study by Gilbertson et al. (2011).

Regarding the future uptake, more than half (53.2%) of the respondents indicated that they would take up at least one of the selected measures the following year, which indicates an anticipated increase in the adoption of pro-environmental behaviour through the uptake of WSUD measures. It would thus be beneficial for the relevant stakeholders to look into why this is the case. However, as Charalambous et al. (2018) argued, as well as Schirmer and Dyer (2018), surveys can act as tools to foster environmental awareness, which could explain the reported increase in the future uptake of selected WSUD measures. It is also important to note that actual uptake might be lower due to 'social desirability bias' – whereby respondents project pro-environmental behaviour in the presence of fieldworkers, which would make the actual uptake of the measures much lower.

The order of *present* uptake ranges from GWR systems (31.6%) to RWH (27.6%) and PP (11.2%). This thus provides insight into the types of WSUD measures preferred by most urban households and, consequently, the types of WSUD measures that stakeholders could promote, subsidize, or even mandate households to take up, i.e., if the need arises. However, the misinterpretation of GWR systems as general GWR – which includes manual GWR, or rather the bucket collection and conveyance of greywater – may have conflated the results, thus making RWH the most taken up measure at the time the survey was administered. The low level of the uptake of PP (11.2%), i.e. at the time of the survey, may allude to the need for educational campaigns, including the active dissemination of information, on various types of PP available to households, which landscape architects could help facilitate. This kind of awareness building could – through the development of environmental values and the provision of increased surface options for households – result in the increased uptake of PP.

Regarding the effect of settlement types on the household uptake of selected WSUD measures – the uptake of all three selected WSUD measures was most pronounced in suburbs and satellite towns, as opposed to township areas, which suggests that WSUD should also be tailored differently to settlement types with different socio-economic conditions. This was also the case across the Cities of Cape Town and Tshwane. The higher uptake of WSUD measures in the suburbs can be attributed to the fact that water is generally used more diversely in suburban areas, and as recommended by Fisher-Jeffes, et al. (2017), "…it would be important to encourage the installation of RWH [and similar] systems in [contexts whereby] water is used as diversely as possible" (Fisher-Jeffes et al., 2017, p. 86). This, therefore, provides insight into the type of areas (or settlements) in which the uptake of WSUD measures can be prioritised – in an effort to yield optimum results.

With regards to the second research objective, the *use of existing water-saving* measures (i.e. constant flow regulators, smart metering and water-saving showerheads), a household's *income area*, as well as its house (i.e. dwelling) or home-*ownership* status – emerged as significant predictors of urban households' uptake of selected WSUD measures. This means that households with existing pro-environmental behaviour, as indicated by their existing use of water-saving measures; households situated in relatively higher-income areas, which is indicative of the respective households' income; as well as households residing in homes that they own, as opposed to tenant households – are more likely to take up selected WSUD measures than their counterparts. This thus provides insight into the types of households that should be targeted in efforts to promote that uptake of the measures.

For instance, while incentives can be used to encourage uptake in households characterised by factors that have been found to most likely influence the uptake of selected WSUD measures, education campaigns – which several scholars have found to have shaped people's pro-environmental values (Bjornlund et al., 2013; Zou et al., 2015; Schirmer & Dyer, 2018; Amodeo & Francis, 2019), which in turn fosters their pro-environmental behaviour (Pinto & Maheshwari, 2010; Gilbertson et al., 2011; Bjornlund et al., 2013; Zou et al., 2015; Campisano et al., 2017; Schirmer & Dyer, 2018; Amodeo & Francis, 2019) – may be used to equip and encourage households that are not necessarily characterised by the predicting factors, to take up various WSUD measures.

With regards to the rest of the identified possible predictors, a households', results indicate that *proximity to water challenges*, dwelling unit size (i.e. the *size of the house*), *household size*, as well as the *announcement and enforcement of water use restrictions,* appear to have had a noticeable influence on households' uptake of selected WSUD measures – further providing insight into the subsidiary factors or household characteristics that stakeholders such as municipalities, as well as other water authorities and service providers, could prioritise in an effort to further encourage the household uptake of selected WSUD measures.

However, except for households in the City of Cape Town – whereby households took up selected WSUD measures regardless of their respective stand or property sizes, as well as the relevant water users' age and level of education – households' property sizes (i.e. *size of stand*), the *age of the head of* each *household*, as well as the *highest level of education* in each one, also appear to have had a noticeable influence on the household uptake of selected WSUD measures, particularly in the City of Tshwane – which was a relatively less water-scarce area at the time of the survey. This further indicates the effect of day-zero on households across the City of Cape Town. The need to conserve potable water, as well as secure as much water as possible from a variety of sources, by Cape Town residents, appears to have nullified any effect that possible predictors in question may have had on the household uptake of selected WSUD measures.

Moreover, since a households' proximity to water challenges did not emerge as a significant predictor of WSUD uptake (as determined by the results of the log-linear analyses, which indicated that there were no significant differences in the City of Cape Town and the City of Tshwane, particularly in terms of the effect any of the predictors had on the household uptake of selected WSUD measures) – the effect of day-zero appears to have been an immediate short-term response by households to drastic measures in the City of Cape Town, rather than a contributor towards predictor effects that may lead to the longer-term or more established levels of WSUD uptake. Therefore, extreme cases of water shortage such as the City of Cape Town's day-zero scenario should probably not be seen as primary catalysts for households to take up WSUD; municipal planning and assistance towards the implementation of WSUD at the neighbourhood and household level is likely to remain important, especially in economically stressed settings such as South Africa.

In terms of the third research objective, *assistance to implement water-saving measures* – including constant flow regulators, smart metering and water-saving showerheads, amongst others – as well as *assistance to implement water sensitive design [or WSUD] measures* – including RWH, PP and greywater reuse systems – were perceived as the most effective municipal water demand-side (DSM) instruments to reduce the relevant (or sampled) households' municipal water use, by the two largest proportions of households (70.6% and 65%), respectively. While *fines for increasing use or using water above a certain quantity*, *water rate increases*, as well as the *naming and shaming of our neighbourhood for increasing use or using water above a certain quantity,* were perceived as the most effective municipal water DSM instruments by the smallest proportions of the sampled households (25.9%, 22.4% and 12.5%), respectively. The results, therefore, indicate that households prefer constructive rather than punitive measures. As highlighted by Mukheibir et al. (2014), in order to ensure the sustainable and long-term uptake of selected WSUD measures, it is important to encourage user acceptance, or rather households' acceptance of selected WSUD measures – and to achieve this, stakeholders would have to take household preferences for municipal water DSM instruments and WSUD measures into consideration. Moreover, in an effort to enhance user acceptance, investigations into the types of water-saving measures that households prefer may be beneficial for stakeholders.

Furthermore, except for *general water restrictions* – whereby a significantly larger proportion of households across the City of Cape Town (52.4%) perceived general water use restrictions as the most effective municipal water DSM instrument than households in the City of Tshwane (42.5%) – no significant differences between the Cities of Cape Town and Tshwane were observed, i.e. with regards to the rest of the intruments. Therefore, the role of general water use restrictions, as well as the acceptance of the instrument by households across the City of Cape Town, as part of the efforts introduced to curb the effects of a then imminent day-zero – is indicative of the potential effectiveness of introducing general water use restrictions as a municipal water DSM instrument for areas facing severe water shortages, particularly in South Africa.

Notably, *assistance to implement water sensitive design measures* was perceived as the most effective municipal water DSM instrument by the largest proportion of suburban households across the City of Cape Town (61.4%); therefore suggesting that many of these suburban households across the City of Cape Town may have already implemented several water-saving measures in response to the water crisis, and thus recognised the uptake of selected WSUD measures as the next step towards improved household water conservation, as a result.

6.3 Summary of Policy and Planning Practice Recommendations and Research Directions

As outlined earlier, four possible directions for taking research on the urban household uptake of WSUD measures, at least in the South African context, have been identified, which include (1) the application of the TPB to help determine or predict the household uptake of WSUD measures; (2) the use the VAIL framework to analyse the effect of value and norms, awareness, identity, as well as lifestyle and life stage factors on the household uptake of WSUD measures; (3) exploring household preferences for various municipal incentives towards taking up WSUD measure(s) as a municipal water DSM instrument; as well as (4) an exploration of exemplary cases of the household uptake of WSUD measures in order to determine unique combinations of factors (i.e. predictors) that appear to contribute towards innovative cases of household uptake of WSUD measures.

In terms of the indicative recommendations for policy and planning practice, the aesthetics improvement of the technologies and infrastructure associated with each of the selected WSUD measures is recommended for households in general, while the introduction and enforcement of legislative mandates (i.e. in the form of building codes and development controls that outline the compulsory uptake of selected WSUD measures), general water use restrictions, as well as price DSM instruments such as water tariff increases, are recommended to curb the water demand and encourage the uptake of selected WSUD measures, particularly for households in areas characterised by water scarcity and severe water shortages. For households situated in water-secure, or less water-scarce areas – educational campaigns on WSUD measures, as well as the dissemination of similar information through the administration of household surveys and the conducting of research studies on WSUD is encouraged; along with the provision of subsidies or incentives to install, retrofit, or take up selected WSUD measures in water-intensive households, as well as households that can afford to cover a portion of the installation costs (e.g. suburban households), in order to minimise municipal spending. However, to validate this recommendation, additional investigations into the association between actual household water use and settlement type would have to be undertaken.

Overall, results from this particular study indicate that there is potential for selected WSUD measures to be taken up on a large scale by urban households across South Africa. The reported future uptake of one or more of the selected WSUD measures (53.2%) partially indicates this. However, it would be an advantage to undertake investigations into why this is the case, i.e. in an effort to harness those catalysts. Moreover, households characterised by the existing use of water-saving measures, as well as those situated in the middle to high, and high-income areas, as well as those residing in homes that they own – were revealed to have a significant likelihood of taking up the measures in question. Thus, targeted efforts to promote the household uptake of WSUD measures directed at such households, are likely to guarantee, increase and accelerate WSUD uptake – which is what this study ultimately aims to achieve.

6.4 Implications of the Research Findings

In terms of the overall implications of the study's findings, as mentioned earlier, there appears to be potential for the large scale household uptake of WSUD in South Africa. This potential is evident in the reported increase in the future uptake of selected WSUD measures. Therefore, indicating that it may be worthwhile for municipalities, as well as various other water authorities and service providers, to invest in WSUD. The findings also provide insight into the type of households, particularly household characteristics that should be targeted or prioritised when formulating policy aimed at promoting the household uptake of WSUD measures, which also reflects the embedded potential of WSUD uptake in South Africa at household level.

The findings further indicate that household preferences are evident and as informed by the literature, preferences are indicative of user acceptance, which has been commonly found to predict uptake. Moreover, considering the normative stance that planning should be inherently democratic, as well as a systems perspective that social aspects form as much part of sustainable development (Benaim, et al., 2008), a key finding is that there appears to be sufficient acceptance of WSUD at household level to warrant policy and planning interventions to encourage the implementation of WSUD at household level. Furthermore, the involvement of households (which form a large part of municipal water users) in efforts towards the establishment of water sensitive cities (WSCs), i.e. through the uptake of WSUD measures – may well accelerate efforts and make the process more efficient.

Furthermore, although user acceptance appears to be evident in both case areas, day-zero seems to have had an 'in the moment' effect on WSUD uptake in the City of Cape Town. However, scenarios such as the City of Cape Town's day-zero, i.e. severe water shortages, shouldn't necessarily be regarded as sufficient to cause more permanent behavioural change or WSUD uptake, at least considering the role of influencing factors. This was partly evident from the loglinear analyses that showed that the nature of the effect of the different factors on uptake (e.g. household size), as per our analytical framework, did not differ significantly between the two cities. Thus highlighting the importance of policy, as well as municipal planning practices and assistance towards the uptake of Water Sensitive Urban Design measures at the neighbourhood and household level, especially in contexts similar to South Africa.

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APPENDIX 1: QUESTIONNAIRE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Towards more effective instruments for demand side management of water in South Africa: A focus on urban household water use
Council for Scientific and Industrial Research

University of Pretoria

SURVEY

Control information	
Team number:	**Interview number:**
Interviewer names:	
Suburb:	**Municipality:**
Sex of person interviewed (please circle): M/F/Other/Unsure	**Race of person interviewed (please circle): Black/White/Coloured/Indian/Other**

Date			Result	Results code	Time Beg	Time End
DD	MM	YYYY		1. Complete		
				2. Partial		
				3. Refused		
				4. No one currently at home/residents temporarily absent		
				5. Uninhabited house		

SECTION 1 – WATER SAVING PRACTICES

1. What do you think are water saving techniques?

2. Does your household implement any water saving techniques (i.e. try to save water)? Tick only one option.

☐ Yes, many ☐ Yes, some

☐ Not really ☐ No, none [If you select this option, then go to **SECTION 2**]

3. What does your household do to save water?

4. Of the things you've mentioned to save water, what do you find easy to do?

5. Of the things you've mentioned to save water, what do you find difficult to do? Why is it difficult?

6. Which one of your water saving techniques do you think saves the most water? And why?

7. When did you start to save water? Tick only one option.

☐ More than 10 years ago ☐ About 5 to 10 years ago

☐ 2 to 5 years ago ☐ Less than 2 years ago

☐ We have not really started to save water, yet [If you select this option, then go to **SECTION 2**]

8. What was the main trigger to start saving water in your household?

a. Why would you say it was the main trigger to save water?

9. **If the respondents' answer to Question 8 was 'water restrictions' as the main trigger, answer this question (Question 9). If the respondent did not mention 'water restrictions' as the main trigger, skip Question 9 and move to Question 10.** If the water restrictions are lifted, which of the water saving techniques you have mentioned will you keep on doing? And why?

10. Apart from the water saving techniques you've mentioned above, is there anything else you think your household could do to save more water?

☐ Yes ☐No

a. If yes, what else could you do to save water?

Go to SECTION 3

Skip SECTION 2 (questions in red)

SECTION 2 - These questions are only for households that up to this point have indicated that they do not save water i.e. you have skipped Questions 3 – 10.

11. What do you think your household could do to save water?

12. Of the techniques mentioned, what do you think would be: a. Easy to do? b. The most difficult to do? c. Would save the most water?

13. What would be needed to convince your household to start saving water?

Continue to SECTION 3

SECTION 3: WATER USE PERCEPTIONS **Please show the show cards for Questions 14, 15 and 16 to the respondent and ask them to choose the most appropriate options.**

14. Please rank the following municipal instruments from 1 (being most effective) to 7 (being least effective) that would cause your household to reduce future municipal water use:	Ranking out of 7
General water restrictions	
Assistance to implement water-saving measures (e.g., constant flow regulators, smart metering, water-saving shower heads, etc.)	
Assistance to implement water-sensitive design measures (e.g., water harvesting, grey-water recycling, permeable paving, etc.)	
Tax incentives for reducing or limiting water use	
Water rate increases (simply increasing the cost of water to meet demand)	
Fines for increasing use or using water above a certain quantity	
Naming and shaming of our neighbourhood for increasing use or using water above a certain quantity	
Not applicable – I/we do not intend to reduce our future municipal water use	

15. Please rank the following information packaging options from 1 (being most effective) to 8 (being least effective) that would cause your household to reduce future municipal water use:	Ranking out of 8
Receiving water saving tips	
Receiving a breakdown of the tariff structure and placing your household's consumption in the tariff blocks	
Receiving information about monthly and annual financial gain from reducing consumption	
Receiving information about monthly and annual financial loss from not reducing consumption	
Receiving a comparison of your household's consumption to the average consumption in the neighbourhood	
Receiving a plea to save water by reducing your consumption by 10%	
Receiving a plea to save water in order to avoid future water restrictions	
Receiving a recognition by having the name of your neighbourhood published on a municipal website if your neighbourhood is one of the top water savers	
Not applicable – I/we do not intend to reduce our future municipal water use	

16. Please indicate the extent to which you agree or disagree with the following statements (followed by 5-point Likert scale, i.e., 'strongly agree', 'agree', 'neither agree nor disagree', 'disagree', and 'strongly disagree'):	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
We are approaching the limit of the number of people the earth can support.					
Humans have the right to modify the natural environment to suit their needs.					
Humans are severely abusing the environment.					
The earth has plenty of natural resources if we just learn how to develop them.					
Plants and animals have as much rights as humans to exist.					
The balance of nature is strong enough to cope with the impacts of modern industrial nations.					
Despite our special abilities humans are still subject to the laws of nature					
The so-called "ecological crisis" facing humankind has been greatly exaggerated					
The balance of nature is very delicate and easily upset					
Humans will eventually learn enough about how nature works to be able to control it					
The so-called "ecological crisis" facing humankind has been greatly exaggerated					
The balance of nature is very delicate and easily upset					
Humans will eventually learn enough about how nature works to be able to control it					
We are willing to pay more to be able to use more water					
There is enough water in the city for us to use as much as we want to use					
There is enough water in South Africa for each household to use as much as they want to use					
Nobody owns water so it should be free					
There is enough water in SA, the government just needs to make a					

plan to get it to us					
Technologies are available to supply the water required					

(Adopted from the New Environmental Paradigm (NEP) scale) (Hawcroft & Milfont, 2010))

SECTION 4: PERCEIVED HOUSEHOLD WATER USE (PAST, PRESENT AND FUTURE)

17. What is the estimated average monthly amount of municipal water <u>in litres</u> that your household used this time last year compared to now, and what do you think it will be this time next year? You do not have to provide exact amounts, estimates will do. If you moved to this address in the last 12 months, skip the column 'this time last year'. If you are planning to move from this address within the next 12 twelve months, please make an estimation as if you would have stayed.	This time last year	Now	This time next year
Estimated average monthly amount of municipal water in litres			
Not sure			

18. Please provide a rough breakdown (out of 100) of the proportion of municipal water that your household typically used for each of the following this time last year compared to now, and what you think it will be this time next year. You do not have to provide exact percentages, estimates will do, but please check that your percentages for each column adds up to 100. If you moved to this address in the last 12 months, skip the column 'this time last year'. If you are planning to move from this address within the next 12 twelve months, please make an estimation as if you would have stayed.	This time last year	Now	This time next year
Consumption by persons and animals i.e. for drinking and cooking food			
Household activities resulting in 'black water' i.e. water from toilets			
Household activities resulting in 'grey water' i.e. water from bathroom basins, baths and showers, kitchen sinks and dishwashers, as well as laundry basins and washing machines			
Irrigation for watering of lawns, gardens and pot plants			
Irrigation for fruit and vegetable gardens			
Topping up water features (fountains and ponds)			
Topping up swimming pool			
Washing vehicles			
Other (Please specify…………………………………………)			

19. How often do you wash your car or have your car washed? Tick only one option.

☐ Never (Skip a and move to Question 20) ☐ Weekly

☐ Every fortnight (2 weeks) ☐ Once a month

☐ Every second month ☐ Twice a year

a. If you wash your car, how do you wash your car?

SECTION 5: WATER SOURCES

20. What is your main source of household drinking water and preparing food (tick only one option):	Tick the appropriate box
Municipal water (metered water with indoor taps and/or taps on the property) (Skip Question 21)	
Borehole water	
Communal tap	
Natural source of water (e.g., rainwater, river/stream, fountain or dam)	
Other (Please specify…………………………………………)	

21. **Skip this question if you ticked 'municipal water' for Question 20.** If you answered 'borehole water', 'communal tap', 'natural source of water' or 'other' to Question 20, how far is this source from the house? **Note to interviewer: if the respondent does not know the distance but can point it out to you, please estimate what the distance is.** Tick only one option.

☐ Less than 200 metres
☐ 201 – 500 metres
☐ 501 metres – 1 kilometre
☐ More than 1 kilometre
☐ Do not know

22. What is your main source of water for the following (tick only one per column):	Other in-house domestic uses e.g. bathing, washing dishes and laundry?	Outdoor purposes e.g. for a swimming pool, ponds and fountains, gardening and washing cars?	Irrigation purposes i.e. a system to water your plants outside?
Municipal water (metered water with indoor taps and/or taps on the property)			
Borehole water			
Communal tap			
Natural source of water (e.g., rainwater, river/stream, fountain or dam)			
Other (Please specify………………………………)			

23. How do you irrigate? And how often?

24. Have you been supplementing (i.e. an additional water source other than your primary water source) your water supply during the past few years with a borehole or well or rainwater harvesting tank etc.? ☐ No (Skip a – c and move to Question 25) ☐ Yes If Yes, then: a. With what did you supplement your water supply? And what are you using it for? b. When did you start to supplement your water supply, and why? Estimate number of years/months/days. c. How much water that you use comes from this alternative source? Estimate a percentage.

SECTION 6: CURTAILMENT MEASURES (PAST, PRESENT AND FUTURE)

Please show the show cards for Question 25 to the respondent and ask them to tick all applicable options.

25. Which of the following water-saving measures with regard to municipal water did your household use this time last year compared to now, and which do you think you will use this time next year? If you moved to this address in the last 12 months, skip the column 'this time last year.' If you are planning to move from this address within the next 12 twelve months, please make an estimation as if you would have stayed. Tick all applicable options.	This time last year	Now	This time next year
Constant flow regulator			
Smart metering			
Water-saving shower heads			
Dual flush toilets			
Eco-settings on dishwashers and washing machines			
Timed sprinklers			
Manual grey-water reuse (using buckets)			
Other (Please specify……………………………….)			
Don't know			
Not applicable			

SECTION 7: EFFICIENCY MEASURES (WATER-SENSITIVE DESIGN) (PAST, PRESENT AND FUTURE)

Please show the show cards for Question 26 to the respondent and ask them to tick all applicable options.

26. Which of the following measures did your household use this time last year compared to now, and which do you think you will use this time next year? If you moved to this address in the last 12 months, skip the column 'this time last year.' If you are planning to move from this address in the next 12 months, please make an estimation as if you would have stayed. Tick all applicable options.	This time last year	Now	This time next year
Rainwater harvesting (the collection of rainwater from roofs into storage tanks, e.g., JoJo Tanks)			
Grey-water reuse systems (retrofitting plumbing in order to reuse water from bathroom basins, baths and showers, or kitchen sinks and dishwashers, or laundry basins and washing machines for irrigation, flushing toilets, outdoor purposes, etc.)			
Permeable paving (using sustainable materials and techniques that allows water to seep through the paving into the ground)			
Don't know			
Not applicable			

SECTION 8: WATER RESTRICTIONS AND REGULATIONS

The following questions are about <u>current and past</u> water restrictions in your area. **Please show the show cards for Questions 28 and 29 to the respondent and ask them to tick all applicable options.**

27. When was the last time your municipality implemented municipal water restrictions in your neighbourhood? Tick only one option.

☐ There have never been municipal water restrictions in my neighbourhood, or at least none in the last 12 months (Skip a – c and move to Question 28)

☐ Municipal water restrictions are currently in place in my neighbourhood! (Go to question a - c)

☐ The last time was more-or-less……………………………….…. [month and year] (Go to question a - c)

☐ Not sure (Skip a – c and move to Question 28)

a. What did/do the water restrictions entail?

b. Has your water use been influenced by the **announcement** of current or past city water restrictions?

☐ Yes ☐ No

c. Has your water use been influenced by the **enforcement** of city water restrictions i.e. issuing of fines or warnings.

☐ Yes ☐ No

i. [If water restrictions are still in place] When did the city start to enforce the water restrictions? __________

ii. How did/does the city enforce the water restrictions?

28. How did you primarily hear/find out about the last time your municipality implemented municipal water restrictions in your neighbourhood? Tick all applicable boxes and circle the one that was the most effective in creating awareness/conveying the message to you.	Tick all applicable boxes
Municipal - printed bill/pamphlet/notice	
Municipal - email message	
Municipal – website	
Management agency/body corporate/residents' association - printed pamphlet/notice	
Management agency/body corporate/residents' association - email message	
Management agency/body corporate/residents' association - website	
Printed newspaper	
Online newspaper	
Radio	
Television	
Social media (e.g., Facebook, Twitter, WhatsApp group, etc.)	
Word-of-mouth (e.g., talking to family, friends, or neighbours, etc.)	
Other (Please specify……………………………….)	
Don't know	

29. How would you primarily prefer to hear/find out about future municipal water restrictions in your neighbourhood? Tick all applicable boxes.	Tick all applicable boxes
Municipal - printed bill/pamphlet/notice	
Municipal - email message	
Municipal – website	
Management agency/body corporate/residents' association - printed pamphlet/notice	
Management agency/body corporate/residents' association - email message	

Management agency/body corporate/residents' association - website	
Printed newspaper	
Online newspaper	
Radio	
Television	
Social media (e.g., Facebook, Twitter, WhatsApp group, etc.)	
Word-of-mouth (e.g., talking to family, friends, or neighbours, etc.)	
Other (Please specify……………………………….)	
Don't know	
Not applicable – I/we usually ignore municipal water restrictions	

30. What is the reason/s for your choices in Question 29?

SECTION 9: REPARATORY MEASURES (PAST, PRESENT AND FUTURE)

Please show the show cards for Question 31 to the respondent and ask them to tick the most appropriate options.

31. In the last year how frequently did your household experience the following leakages on the property or inside the dwelling? Tick all applicable options	None	Infrequently	Sometimes	Frequently
Outdoor pipes				
Outdoor taps				
Indoor pipes				
Indoor taps				
Geyser(s)				
Toilet cistern(s)				
Other (Please specify……………………………….)				
Don't know				

Thank you for answering all these questions to help us understand the situation in your household. There are a few more last things to clarify.

SECTION 10: ACTUAL HOUSEHOLD WATER USE AND ELECTRICITY USE (PRESENT)

Please show the show cards for Question 34 to the respondent and ask them to tick the most appropriate option.

32. Would you be willing to share a typical month's municipal bill with us (e.g. when all household members were at home for the whole month)? Kindly ask your fieldworker to help you with the bill if necessary

Note: If you rent would you be able to obtain these figures from the landlord?

a. Actual amount and date of bill _______________

b. Not applicable (e.g., sectional title, or borehole, communal standpipe, or natural source as primary source

of water for household use)

c. No municipal bill available at the moment

33. How do you think **your water** bill compares to other households similar to your household in your area?

☐ Much lower ☐ Lower ☐ Similar ☐ Higher ☐ Much higher

☐Don't know ☐Refuse to answer

34. Which one of the following statements is the most applicable to your household's electricity use? (Tick only one)	
We use the bare minimum electricity	
If we put in effort we can use less electricity	
We use the electricity that we need	
We use too much electricity and should be able to save electricity without too much effort	
Why should we use less electricity?	

35. How do you think your **electricity** bill compares to other households similar to your household in your area?

☐ Much lower ☐ Lower ☐ Similar ☐ Higher ☐ Much higher

☐Don't know ☐Refuse to answer

SECTION 11: RECYCLING PATTERNS

36. In the last three months, has your household recycled any dry recyclables (paper, glass, metal, plastic)?

☐ Yes, regularly ☐ No, not at all ☐ Every now and then

37. How do you think your recycling actions compare to other households in your area?

☐ Much better ☐ Better ☐ Similar ☐ Worse ☐ Much worse

☐Don't know ☐ Refuse to answer

SECTION 12: SITUATIONAL FACTORS
Please show the show cards for Questions 39, 40, 44, 45, 51, 52, 53 to the respondent and ask them to tick the most appropriate options.

38. Age of house in years:

☐ less than 10 years ☐ 10-25 years ☐ 26-50 years

☐ more than 50 years ☐Don't know ☐Refuse to answer

a. If you know the exact number of years, what is it? ______________________

39. What is your dwelling type (tick one option only)?	
Free standing house (on a separate stand or yard)	
Single-storey duplex	
Double-storey flats/housing complexes	
Multi-storey flats (more than 3 floors)	
Informal dwelling /shack	
Duet	
Residential (other) Please specify:………………………………………….	
Don't know	
Refuse to answer	

40. Please provide a rough breakdown (out of 100) of the proportion of coverage on your property of each of the following: (You do not have to provide exact percentages, estimates will do, but please check that your percentages add up to 100.)	
Roof	
Impermeable paving (i.e., paving through which water cannot seep)	
Permeable paving (i.e., paving through which water can seep)	
Swimming pool	
Lawn (i.e., short grass)	
Garden (i.e., area of the plot with plants for aesthetic value)	
Fruit / vegetable garden	
Natural/indigenous vegetation	
Other (Please specify……………………………………………………….)	

41. Size of stand: Tick one option only.	
<500 sq m	
500-1000	
1001-1500	
>1500 sq m	
Don't know	
Refuse to answer	

42. Size of house: Tick one option only.	
<35sq m	
35 – 60	
61 – 120	
121 - 240	
241 - 480	
>480 sq m	
Don't know	
Refuse to answer	

43. Household size: Tick one option only.	
Small or single parent (1-3 members)	
Average/nuclear (4 members)	
Extended (4-8 members)	
Large extended (more than 8 members)	
Multiple family (more than one household but with one municipal bill)	
Don't know	
Refuse to answer	

44. Of everybody in the household, what is the highest level of education obtained? Tick one option only.	
Completed junior primary school (Gr 3)	
Completed senior primary school (Gr 7)	
Completed Gr 10	
Completed high school (Gr 12)	
Completed undergraduate degree	
Completed TVET and/or other college	
Completed postgraduate degree	
No schooling	
Don't know	
Refuse to answer	

45. What is your highest level of education obtained? Tick one option only.	
Completed junior primary school (Gr 3)	
Completed senior primary school (Gr 7)	
Completed Gr 10	
Completed high school (Gr 12)	
Completed undergraduate degree	
Completed TVET and/or other college	
Completed postgraduate degree	
No schooling	
Don't know	
Refuse to answer	

46. Age of head of household (if you don't know, estimate an age group i.e. in their twenties, in their thirties etc)

____

☐Don't know ☐Refuse to answer

47. What is your age in years?

____

☐Don't know ☐Refuse to answer

48. Sex representation in the house:

☐ More males than females ☐ Equal number of males and females

☐ More females than males ☐Don't know ☐Refuse to answer

49. Dominant race group in household:

________________________________ ☐Don't know ☐Refuse to answer

50. Do you own or rent the house?

☐ Own ☐Rent ☐Don't know ☐Refuse to answer

51. Which of the following descriptions best resonates with the way you think society should be organised? Tick the most dominant belief you have.	
The best government is absolutely no government. Everything about governments is repressive and therefore must be abolished entirely.	
A single ruler should have control over every aspect of the government and of the people's lives. Everything should be carefully structured, including society. The law must be obeyed.	
The individual takes priority over society. Individuals have the right to make choices for themselves. No person is morally or politically superior to others. Hierarchies are rejected.	
Stability is a precious thing, and change must be made gradually in order to preserve it. Excessive freedom is bad, lets people ignore societal responsibilities and overlook social customs.	
Human beings are social by nature, and society should respect this. Individualism is poisonous. Society, not individuals, should own the property. The government plans the economy; there is no free market.	

Don't know	
Refused to answer	

52. Which of the following descriptions best resonates with the way the majority of people living in your neighbourhood may think? Tick the most dominant belief that you think they share.	
The best government is absolutely no government. Everything about governments is repressive and therefore must be abolished entirely.	
A single ruler should have control over every aspect of the government and of the people's lives. Everything should be carefully structured, including society. The law must be obeyed.	
The individual takes priority over society. Individuals have the right to make choices for themselves. No person is morally or politically superior to others. Hierarchies are rejected.	
Stability is a precious thing, and change must be made gradually in order to preserve it. Excessive freedom is bad, lets people ignore societal responsibilities and overlook social customs.	
Human beings are social by nature, and society should respect this. Individualism is poisonous. Society, not individuals, should own the property. The government plans the economy; there is no free market.	
Don't know	
Refused to answer	

53. What type of water meter is fitted to your municipal water inlet? – show image card with number to each picture and tick the most appropriate option.	
A	
B	
C	
E	
F	
G	
H	
N - None of the above	
Don't know	
Refused to answer	

THANK YOU FOR PARTICIPATING IN THIS SURVEY!

APPENDIX 2: PERMISSION AND CONSENT FORM TO PARTICIPATE IN SURVEY RESEARCH

PERMISSION AND CONSENT FORM TO PARTICIPATE IN RESEARCH: SURVEY

Towards more effective instruments for demand side management of water in South Africa: A focus on urban household water use

You are asked to participate in a research study being conducted by a research team from the Natural Resources and the Environment Operating Unit at the CSIR.

We would like to talk to you about your household's water use behaviour.

1. PURPOSE OF THE STUDY

Our research looks at household water use behaviour in six of the eight South African metropolitan areas by, comparing actual household water use with perceived water use in different dwelling types (houses, flats, informal settlements) and, for a variety of indoor and outdoor activities. The metropolitan municipalities are: City of Cape Town, City of Joburg, City of Tshwane, Ekurhuleni, eThekwini, and Mangaung. We hope that we can help our stakeholders and residents to better understand household water use at local government level and the measures they could take to curb excessive household water use by designing more informed policies and more nuanced household water use practices.

2. PROCEDURES

Your participation will involve the following:

- The survey will take no more than an hour of your time to finish.
- The questions in the survey are about your household's water use patterns.
- A research team member will ask you the survey questions.
- You will need to sign a consent form to protect your rights before the survey starts.
- When we have finished going through the survey, we will ask you if you are willing to take part in a focus group discussion in future. If you agree to this, you will please need to give us your name and contact number. We will only use this information to contact you and will not put it in the research. You can also refuse to take part in the focus group discussion after the survey.

3. POTENTIAL BENEFITS TO SOCIETY

You will not receive direct benefits such as payment. There could be some benefit to society as the knowledge that comes out of the research aims to improve the ability of metros to design better water demand management strategies that are more aligned with water use behavioural patterns of their residents.

4. POTENTIAL RISKS AND DISCOMFORTS

There are no risks to participants taking part in this study. Additionally no person will be harmed or negatively impacted upon if they do not take part in the research.

You can also refuse to take part in the study without any negative impacts on you or your household.

5. PAYMENT FOR PARTICIPATION

We cannot pay you to take part in the survey.

6. CONFIDENTIALITY

We will only report on the research results in general. We will not link your name to anything you say during the surveys, interviews or group discussions that then gets written in reports and other documents.

A research team member will record your answers by completing a survey form. The principal investigator of the study will be responsible for storing all of the electronic research data and documents in CSIR data archives. The hard copy data and documents will be stored in offices that will be locked. The electronic data will be codeword protected and only the research team members will be able to access these.

The research results will be published in peer-reviewed journals, popular media, policy briefs and guidelines and in a video documentary. We will not mention your name as part of these research outputs.

7. COMMUNICATION OF STUDY FINDINGS TO RESEARCH PARTICIPANTS

We will produce an infographic pamphlet and an animated video summarising the research findings of the project and will communicate and disseminate these products in feedback sessions in each of the metropolitan areas.

8. PARTICIPATION AND WITHDRAWAL

You can choose if you want to take part in this study or not. If you decide to take part, you can withdraw at any time. Nothing bad will happen to you if you do not take part in the research. You may also choose to take part in the study but refuse to answer any questions that you do not want to answer. The principal investigator may withdraw you from the study if she feels that this is to your benefit.

9. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact:

Dr Inga Jacobs-Mata
Principal Investigator
ijacobsmata@csir.co.za
South Africa cell: +27-84-674-2470

Ms Karen Nortje
Co-investigator
knortje@csir.co.za

10. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and stop participating without any negative consequences. You are not giving up any legal rights by participating in this study. If you have questions regarding your rights, contact Dr Sandile Ncanana, the CSIR Research and Ethics Committee Secretariat, [R&DEthics@csir.co.za/012 841 4060] at the Research and Development Office.

Fieldworkers note – from here on you should keep the next pages.
Page 1-2 are given to the respondent to keep as reference.

FOLLOW- UP

Please indicate which of the following you **are willing** to participate in (if any), noting that only a **sub-set of respondents** will be selected for these engagements.

Note: Your contact details address will be kept confidential and will not be linked to any of your responses.

A. Are you prepared to participate in a follow-up interview and/or focus group discussion?

Yes I am willing ☐

No, please do not contact me ☐

B. May we contact you about the engagement that you had with a fieldworker?

Yes I am willing ☐

No, please do not contact me ☐

If yes to any of the above, please provide your name, contact details and an appropriate contact time:

Name: ________________________________

Contact number: ____________________________

Email: ____

Best time to contact: ___________________________

Signature of research participant

I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

____________________	______________	__________________
Name of Participant	**Date**	**Signature**

If more than one participant:

____________________	______________	__________________
Name of Participant	**Date**	**Signature**
____________________	______________	__________________
Name of Participant	**Date**	**Signature**
____________________	______________	__________________
Name of Participant	**Date**	**Signature**

Verbal consent (if preferred)

The participant requests verbal consent to be given.

The investigator declares that the participant has given verbal consent.

Place:______________________________

Date: ______________________________

Time:_______________________________

Signature of investigator/interviewer

I ______________________declare that I explained the information given in this document to _________________________ [*name of the participant]. [H*e/she] was encouraged and given ample time to ask me any questions.

Signature of Investigator/Interviewer **Date**

APPENDIX 3: STUDENT RESEARCHER DECLARATION

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATURAL RESOURCES AND THE ENVIRONMENT BUSINESS UNIT

UNIVERSITY OF PRETORIA
FACULTY OF ENGINEERING, BUILT ENVIRONMENT & INFORMATION TECHNOLOGY DEPARTMENT OF TOWN & REGIONAL PLANNING

TPE420 Research report 420

Student researcher declaration

(To be signed by each student and kept on record by the CSIR project leader and UP supervisor.)

1 Title of research project: Urban household water use / Water sensitive urban planning and design

2 I Lethabo Chilwane student number 13187466 hereby declare that I will:

a. Explain the objectives and implications of the research to respondents;

b. Indicate to respondents that their participation in the research is voluntary and that they can withdraw from the research at any stage;

c. Obtain written informed consent from each respondent;

d. Not ask respondents any personal questions (e.g., questions on income, ID number, etc.), or questions beyond the theme of the abovementioned project;

e. Treat all responses of respondents confidentially; and

f. Store the dataset of anonymous survey responses on a password protected personal computer; g, Not distribute the dataset of anonymous survey responses;

h. Not use the dataset of anonymous survey responses for any other purpose other than writing my final year research report; and

i. Not engage in any form of research fraud (e.g., falsifying or distorting data).

Student signature: [signature] Date: 10/09/2019

APPENDIX 4: STUDENT RESEARCHER INDEMNITY

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATURAL RESOURCES AND THE ENVIRONMENT BUSINESS UNIT

UNIVERSITY OF PRETORIA
FACULTY OF ENGINEERING, BUILT ENVIRONMENT & INFORMATION TECHNOLOGY DEPARTMENT OF TOWN & REGIONAL PLANNING

TPE420 Research report 420

Student researcher indemnity

(To be signed by each student and kept on record by the CSIR project leader and UP supervisor.)

1 Title of research project: Urban household water use / Water sensitive urban planning and design

2 I Lethabo Chilwane student number (13/87466 hereby declare that I will:

a. At all times abide by the full fieldwork protocol as set out by the CSIR/UP research team; and

b. Take reasonable precautions in the field to as far as possible ensure my own safety (e.g., have emergency contact numbers at hand, avoid carrying unnecessary valuables, and avoid situations that are potentially or evidently dangerous, etc.)

Student signature: [signature] Date: 16 July 2019