PUBLIC PERCEPTIONS FOR THE ACCEPTABILITY OF RECYCLED WASTEWATER USAGE IN HOUSEHOLDS

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Samiya Gul

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Supervisor: Professor Ivan Gunass Govender (DPA) Date

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Co-supervisor: Professor Faizal Bux (Ph.D.) Date

ABSTRACT

South Africa is a water-stressed country as there is an imbalance between the demand and the supply of potable water. Wastewater reuse is one of the several vital strategies to find the delicate balance between water supply and demand. Reclaimed wastewater not only protects the release of pollutants into the environment but it adds to the supply of potable and non-potable water. However, reclaimed wastewater faces obstacles in sustainable implementation. Many studies have been conducted so far to identify the underlying factors behind the acceptability of wastewater reuse. Public acceptance is the primary threat to the acceptability of these programs or schemes. A noticeable resistance from the communities of different countries has been identified. Given these issues, the objectives of the present study were to evaluate socio-demographic variables including; gender, age, education, religion, marital status and income level on the willingness to use and participate in a reuse plan, to assess the role of knowledge on public acceptance of the recycled water, to identify and study the problems faced by the public towards the acceptability of recycled wastewater usage and to develop a framework to understand the behaviour of the people towards the reuse of wastewater. The study adapted well-structured questionnaires to collect the data. Proportionate random sampling was used with a sample size of 298 responses. The data were analysed through MS Excel, SPSS v 22.0 and AMOS v 24.0 to yield descriptive and inferential statistics. Structural Equation Modelling (SEM) was used to provide estimates and test the hypothesised relationships. The study identifies the critical antecedents of the behaviour of wastewater reuse, namely, trust, past experience, subjective norms, perceived behavioural control, attitude and intention and tests the relationships using SEM. It further suggests that a significant relationship exists between the variables and the acceptability of wastewater reuse. The other findings were that flushing toilets are mostly accepted (90%), followed by watering gardens (86%), washing clothes (68%) and washing dishes (60%). The acceptance for favourable applications among participants from all religions is highest for toilet flushing, followed by watering gardens, washing clothes, washing dishes, growing food crops, swimming, and at last drinking. Financial incentives and reduced monthly costs on the recycled water were found to help accept the wastewater reuse. The study presents a broad and integrated framework of behaviour towards the acceptability of wastewater. Therefore, the study is an essential contribution toward the acceptability of wastewater reuse, and water stakeholders may use the study's implications to increase public acceptance and alleviate challenges for water reuse. The study recommends that the public should be provided with the education and information on recycling wastewater reuse benefits and risks to achieve both environmental protection and sustainable development.

DECLARATION

Title of Thesis: - Public perceptions for the acceptability of recycled wastewater usage in households

By Samiya Gul (21959372)

This study is the author's original work and has not otherwise been submitted for any degree or diploma to any university. Where use has been made of the work of others, such has been duly acknowledged in the text.

_____ 13-04-2023

Signature of Student Date

(Mrs Samiya Gul)

DEDICATION

This thesis is dedicated to my parents, siblings, and husband, who encouraged my pursuit of knowledge.

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"To speak gratitude is courteous and pleasant, to enact is generous and noble, but to live gratitude is to touch Heaven."

-Johannes A. Gaertner

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Samiya Gul (April 2023, Durban)

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AMOS	Analysis of Moments of Structure
ATT	Attitude
BEHV	Behaviour
CFA	Confirmatory Factor Analysis
DWAF	Department of Water Affairs and Forestry
DWTP	Drinking Water Treatment Plant
DWS	Department of Water and Sanitation
EFA	Exploratory Factor Analysis
GDP	Gross Domestic Product
HBM	Health Belief Model
INT	Intention
KMO	Kaiser-Meyer-Olkin test
KZN	KwaZulu Natal
ML/D	Megaliters per day
NGWRP	New Goreangab Water Reclamation Plant
NWRS	National Water reuse Strategy
PBC	Perceived Behavioural Control
PE	Past Experience
SCT	Social Cognitive Theory
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
SNO	Subjective Norm

SPSS	Statistical Package for Social Sciences
TRU	Trust
TPB	Theory of Planned Behavior
US	United States
WWTPs	Wastewater Treatment Plants
WWTWs	Wastewater Treatment Works

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CHAPTER 1

OVERVIEW AND BACKGROUND OF THE STUDY

1.1. INTRODUCTION

Wastewater reuse has been identified as an essential strategy for water resource conservation and global water challenges (Wester *et al.,* 2015). Governmental support, efficient technology, sufficient capital, and people's approval or acceptance are among the essential requirements for the success of wastewater reuse. Reclaimed water serves many benefits, both direct and indirect. Water reuse can provide alternatives to existing water supplies and helps in the increase of overall water availability. It also helps in the rise of agricultural production as irrigation with wastewater helps increase the production yields (Lopes *et al.,* 2015). Thus, water reuse can be used for social, economic, and environmental benefits e.g., an important alternative during the situations like, drought, employment generation, higher productivity water reuse has been recognised as a significant strategy to resolve the water scarcity problem (Saidan *et al.*, 2020). The level of interest and acceptance is likely to increase because of two primary advantages; mitigating the environmental impact of wastewater disposal and creating an additional water supply source. Water reuse is economically friendly and innovative, producing high-quality water at a lower cost than developing a new water supply. The countries successfully adapting the water reuse technologies are the United States of America (USA), Israel and Singapore (Vesey, 2016).

The driving forces of using recycled water are water scarcity and sustainability. According to World Health Organization (WHO), water scarcity, increasing population, food insufficiency and increasing environmental pollution (from untreated wastewater) are the main driving forces for wastewater reuse (WHO, 2006; WWAP, 2017).

1.2. GLOBAL SCENARIO OF RECYCLING OF WASTEWATER

Globally, Australia, the United States, Namibia, and Israel are among the most successful countries in introducing and implementing planned wastewater use for different activities (Tortajada, 2020).

In China, almost 924 wastewater treatment plants have been constructed and supply the recycled water for various purposes such as industrial cooling water, agricultural irrigation, and landscape watering (Zhu *et al.,* 2018). A municipal wastewater treatment plant in the southeastern part of Shiraz (a city in Iran) uses the conventional activated sludge process for wastewater treatment. The various applications of this treatment plant are agricultural, landscape, and

irrigation (Baghapour *et al.,* 2017). Jordan is a successful example with strong community acceptability. Jordan is known as semi-arid to arid country, it is classified as one of the poorest countries in the world in terms of water resources as compared to other countries in the Middle East. There are almost 30 WWTPs, that have successfully replaced the use of freshwater in agriculture for wastewater reuse. The recycled water has been used for agricultural and industrial sectors (Saidan *et al.*, 2020). It has rightly informed and convinced its public regarding the significance of wastewater use in agriculture. The various techniques like newsletters, guidebooks, newspapers on television and radio, websites, and public educational places have increased the acceptance level among the community (Al- Momani, 2011).

The drought conditions are the main driver for water reuse in Australia. Brisbane has been a leader in treating and reusing wastewater. The successful water reuse projects in Australia have used water for toilet flushing, garden watering and firefighting, lawns, gardens, and parks (Nancarrow *et al.,* 2008).

The famous treatment plant of Windhoek, capital city of Namibia, New Goreangab Water Reclamation Plant (NGWRP), is an example of direct potable reuse. For more than 40 years, recycled wastewater has been mixed with drinking water. The technologies used are pre-ozonation, enhanced coagulation, rapid sand filtration and subsequent ozone, biological activated carbon, ultrafiltration, and chlorination. About 14% of the drinking water is reclaimed wastewater (Rodriguez *et al.,* 2009).

The most effective recycled water project in Singapore, NEWater, is considered the most strategic decision. It recycles the available water and is regarded as the best and cheaper than other options, with an acceptance rate of 98%. The reused water has been successfully used for educational and celebratory purposes. About 30% of Singapore's total water use is NEWater, and it is estimated that by 2060, the NEWater capacity will reach 50% (Wang *et al.*, 2019).

In South Africa, the Department of Water and Sanitation (DWS) in the National Water Resources Strategy 2 (2016) have identified water reuse as a priority. Water utilities of KwaZulu-Natal (viz. Umgeni Water and Ethekwini) initiated reclamation projects of wastewater reuse, desalination, and combined desalination with wastewater reuse to cope with the water scarcity in South Africa. The main treatment processes include sand filtration, UF, two-stage RO and UV. In 2010, a natural wastewater reclamation plant was constructed to produce drinking water in Beaufort West, South Africa, with 2300 m3 per day (Olle and Andreas, 2011). A 2 ML/day wastewater reuse treatment project by

Umgeni water is currently under construction at Darvill wastewater treatment works, Pietermaritzburg, for a feasibility study.

Florida and California are the leaders in using recycled wastewater in the United States. Over 230 reuse projects are operating in the US. The recycled water is used for irrigation, agriculture, landscaping, and industrial uses. A famous example of indirect potable reuse is Orange Country in the city of California (Po *et al.*, 2003).

1.3. RECYCLING OF WASTEWATER AND SUSTAINABLE DEVELOPMENT GOALS

All 193 member states of the United Nations General Assembly universally agreed to transform the world with the 2030 Agenda for Sustainable Development in September 2015. The 2030 Agenda is a plan of action for improving people, the planet and prosperity (United Nations, 2018). The main aim of the agenda is to "end poverty in all its forms", to take transformative steps to "shift the world on to a sustainable and resilient path", and to safeguard that "no one will be left behind".

One of the most important and interdependent Goals of SDG 6 is to guarantee the availability and sustainable management of water and sanitation for all. SDG 6 not only explains the problems related to drinking water, sanitation, and hygiene but also the quality and sustainability of water resources worldwide. The eight global targets that are included in this goal are: a) to provide drinking water, b) sanitation and water services, c) treatment and reuse of wastewater and ambient water quality, d) water reuse efficiency and scarcity, e) IWRM including through transboundary cooperation, f) protecting and restoring water-related ecosystems, g) international cooperation and capacity building, h) and participation in water and sanitation management (United Nations, 2018).

Recycling and reusing wastewater and providing quality water to all is one of the worldwide goals of SDG 6. But the freshwater quality is a significant challenge globally. According to the Sustainable Development Goal 6 Report (2018), almost 59% of household wastewater flows from 79 high and high-middle-income countries is reused. The significant challenges for the water sector are improving water quality, wastewater treatment, recycling wastewater from households and industry, reducing diffuse pollution and improving water quality. Recycling, reusing, and recovering can relieve the water scarcity and offer many social, economic, and environmental benefits (United Nations, 2018).

1.4. LEGISLATION/POLICIES/GUIDELINES IN SOUTH AFRICA FOR WASTEWATER RECYCLING

1.4.1. National Water Reuse Strategy (NWRS)

National Water Reuse Strategy (NWRS) is among the main legislative guideline for water reuse in South Africa. According to NWRS, wastewater reuse is a significant part of water resource development. It is considered one of the vital strategies to achieve the delicate balance between water availability and water requirements (Kemp, 2017).

Recycled wastewater is used for several uses, depending on its acceptability and feasibility. High purification technology has made it possible to treat wastewater to the highest degree and make it another water resource. In South Africa, 14% of wastewater is reused, mainly indirectly according to the estimates of department of water and sanitation, (2018). The different laws for regulating and controlling the activities of wastewater reuse projects are:

a) National Water Act (Act 36, 1998)

b) Mineral and Petroleum Resources Development Act (Act 28, 2002)

c) National Environmental Management Act (Act 107, 1998)

d) National Environmental Management: Waste Act (Act 59, 2008)

e) Water Services Act (Act 108, 1997)

f) Coastal Management Act (Act 24, 2008)

g) Municipal bylaws

1.4.2. Objectives of NWRS

I. Promote good decision-making.

The decision-making occurs at every level and varies across different levels in a wastewater reuse scheme. For example, it can be for a building or factory at a local group or a wastewater treatment facility at the city level. Sound decisions are required at different treatment levels with various stakeholders to implement wastewater reuse successfully. NWRS aims to encourage sound decision-making among all stakeholders of water reuse.

II. To support a clear policy and legislative environment.

Several regulatory authorizations and frameworks are required to establish water reuse projects effectively. There is a need for a proper legislative environment for the water reuse projects, which should not conflict with existing

policies, laws, and legislation. Existing policies relevant to fresh water sources and wastewater are documented in national acts and municipal bylaws in South Africa. Due to the combined nature of water reuse projects involving fresh water supply using wastewater, existing policies and regulatory frameworks may not be favorable for their successful implementation. Therefore, NWRS focus on developing clear and practical legislative guidelines for water reuse projects.

III. To assess incentives

One of the advantages of water reuse is that it is cost-effective compared to other water supply options. Due to the low-cost options, households and businesses opt for water reuse for their water needs. Municipalities also prefer low-cost options to allocate the water requirements at the time of water scarcity and control the surge in water prices. Recycled wastewater will be preferable, provided it is cheaper and subsidized. However, if the freshwater supplies are heavily discounted, water users will not prefer recycled wastewater. Therefore, a balance is required between the incentives offered and the cost of the recycled wastewater.

IV. Supporting decision-making and implementation

Information plays a significant role in making good decisions. The three aspects of information are: creating awareness of the benefits and acceptance of wastewater reuse among users, providing guidelines for implementing the water reuse projects and using the best approach for measuring the alternatives to balance the water requirement and its availability.

V. Selecting technology

The right treatment technology is essential for the implementation and operation of water reuse projects. Thus, selecting and performing appropriate technology is one of the big decisions. To achieve this objective, certain decisions are to be considered:

Select knowledgeable and competent staff (agency or organization) to manage the reuse projects.

Procuring the best technology considering both performance and cost factors.

Ensuring the availability of local knowledge for the technology.

Providing training to reuse project staff.

VI. Public education and awareness

The water reuse implementation requires a well-designed and intensive public education program to create knowledge about the benefits of water reuse among communities. In this process, different departments, institutions, and

companies are involved in the awareness and information programs. A major issue has been identified as a remarkable resistance from the public to water reuse and undesirable public opinion. Therefore, it is significant to create awareness of the benefits of water reuse among the masses. These programs aim to increase knowledge and understanding and help in decision-making for accepting recycled wastewater. The other significant challenges to accepting recycled water are poor operation and maintenance of municipal wastewater treatment plants. These issues need to be appropriately addressed to gain the acceptance of water reuse.

VII. Supporting technology innovation and development

The success of the acceptability of recycled wastewater depends on the performance of the technology. There are many water reuse projects in South Africa, and it is known as a leading innovator in technology, especially for the treatment of acid-mine drainage. One of the focuses of NWRS is to promote innovation in the water reuse sector for the global market.

The other objectives are organizing the staff for the service delivery, imparting the training, developing the technical skills for operating the water services and financing water reuse projects.

1.5 WATER SERVICE DELIVERY AND LEGISLATIVE FRAMEWORK IN SOUTH AFRICA

The state is vital in delivering its citizens a wide range of services. Among the essential services a state provides, water service delivery is the most critical one (Koma, 2010). Therefore, this section details legislative structures relevant to water service delivery in South Africa.

1.5.1. Constitution of Republic of South Africa, 1996

South Africa is a democratic country, giving all citizens the right to avail the delivery of essential services like water (Koma, 2010). Section 27 (1) of the South African Constitution specifies that all citizens have the right to access health care services and sufficient water. The Constitution further stipulates that a citizen's status should not affect how he or she is treated, regardless of whether he or she is rich or poor, young, or old, man or woman, black or white. As a result, the people living in the vulnerable or informal sectors get access to essential services. The primary aim is to treat all citizens fairly, just and equally.

Section 9 (3) of the Constitution stipulates that based on race, gender, sex, colour, marital status, language, age, or disability, no one should be discriminated against unfairly or unequally, directly, or indirectly. Additionally, Section 152 (1) states that some of the primary objectives for the local government are:

- To deliver democratic and reliable government for local communities,
- To provide the service delivery to all the citizens in a justifiable manner,
- To encourage a safe and healthy environment and
- To promote public participation in matters of government.

These objectives ensure that local governments act democratically and responsibly and provide essential services to all citizens regardless of where they live.

1.5.2. Promotion of Administrative Justice Act, 2000

Until 1994, there was no equal recognition of the rights of all citizens in South Africa. That means if any citizen was poorly treated or misbehaved by any government official, no action was ever taken for justice for the victim. However, after the democratic elections, Section 33 (108) of 1996 protects the significance of giving written reasons to the citizens for maltreating them. For this, the government came up with the new Act, Promotion of Administrative Justice Act No 3 of 2000, which confirms that, where the essential services are concerned, the citizens possess the right to seek justifications for the poor services provided to them. The people have an option to this Act if they feel dissatisfied with delivering essential services such as water.

Therefore, the government is bound to provide the basic services promptly irrespective of the place of living through this legislative commitment Act, 2000 (Hughes, 2012).

1.5.3. White Paper on Transforming Public Service Delivery, 1997

Until 1994, South Africa had a history of apartheid, having a huge separation and disempowerment among the Black African population. The apartheid system had created vast inequalities in access to the essential services and resources prevalent today. However, the democratic election ensured legislation to provide for the basic needs of all citizens. The government adopted the White Paper on Transforming Public Service Delivery (1997) as a Code of Conduct for all the government employees and the local government. This White Paper, *Batho Pele* (People first), entails that the rights of the citizens are prioritized. The aim of this White Paper is that all the citizens are treated regardless of status and residence. According to White Paper, service delivery must be transparent, reliable, standard, and due consideration to the value of money. In other words, it is the transformation agenda that ensures the delivery of services both efficiently and effectively to meet the needs of the citizens. The success of service delivery will only be considered effective when the delivery of services meets the needs of the citizens of South Africa. This is possible when the local government adheres to the principles of the White Paper. The government is bound to provide services to the people living in rural and informal settlements. There should be no discrimination among citizens based

on race or socio-economic level. Therefore, considering these Acts and laws, this study also involved all the races of Durban city to study the perception for the acceptability of wastewater reuse.

1.5.4. Water Services Act, 1997

This Act ensures that all citizens have equal rights to access the basic water service. Water Services' Development Plans (WSDPs) are to be adapted and developed by the water service authorities. To achieve this objective, all citizens have the right to access water. The Act stipulates:

- That the water service authorities are responsible to their citizens regardless of residence,
- All the citizens of South Africa should have equal and fair access to a water and sanitation supply.

A study has been done to compare this system with principal-agent relations. It states that government acts as a principal, which always tries to save when it comes to service delivery, whereas citizens act as agents who wish to increase their benefits from services (Peter *et al.,* 2007). This Act demands that services be delivered irrespective of where they reside, whether urban, semi-urban or informal settlements and rural areas (Siebrits *et al.*, 2014).

1.5.5. National Water Act, 1998

The Department of Water and Sanitation manages, protects, develops, and controls the water services set by the National Water Act. To fulfil this, the local government is assigned to provide basic needs, including water, equally irrespective of where one resides. An effort has been made to transform the policies and legislation to develop the state as an equitable society. As a result, no racial group can complain of any service deficit i.e., water shortages (Malakoana, 2016).

1.5.6. White Paper on transforming local government (1998)

The White Paper stipulates that local government should be democratic and responsible to all the citizens. The local government must work hard to bring transformation and development in service delivery. The White Paper aims to function democratically, motivating the local government to work with the local communities to deliver the necessities. The citizens, including the residents of informal settlements, need to participate in the policy-formulation processes such as management, budgeting, and planning (Malakoana, 2016).

1.6. SOUTH AFRICAN HISTORY AND WATER SERVICE DELIVERY ISSUES IN ETHEKWINI MUNICIPALITY

People from informal settlements did not have access to water services. They depended solely on river water, even for drinking purposes. The dependence on unhealthy and unsafe water from rivers and streams created many difficulties for the poor citizens. The burden of fetching water created many problems for women and children. The political restrictions imposed during the colonial period gave rise to several inequalities in both resource allocation and services. They were deprived of basic amenities like education, health services, and clean water. But after 1994, with the advent of the new political rules, there was a dramatic shift in the quality and equitable availability of basic amenities (water services). As a result, their quality of life and economic status got improved. Water services and new water connections were easily accessible to more people (Nnadozie, 2013).

There was a significant rise in households with piped water from 1996 to 2001 (Statistics South Africa, Census 2011). Municipalities in South Africa provides clean water that is too safe to drink directly from the tap. eThekwini Municipality transformed the whole approach of delivering good quality water and sanitation services and became the leader in the public sector for water services. For these world-class services, in 2014 in Sweden, eThekwini Municipality won the famous Stockholm Industry Water Award. In 2015, it was again voted the Municipality of the Year in Africa-by-Africa Utility Week. It has improved the lives of about 500000 residents by providing access to quality water services.

1.7. INFORMAL SETTLEMENTS AND DELIVERY OF WATER SERVICE

After 1994, the democratic government guaranteed access to water services and the country's overall development. Also, the Constitution confirmed the equitable and fair delivery of services to all South African citizens. Hence, there was fast migration of people to the urban areas due to job opportunities, poverty eradication and access to better quality services. The citizens that migrated illegally erected living structures and shacks (without consulting the municipalities). Once settled, they expected the government to provide them with essential housing, water, and sanitation services. This posed severe challenges for the government as they had to offer these services and ensure that citizens do not live in unsafe conditions (Mbeki *et al*, 2014).

The municipalities failed to provide services to the people living in the informal settlements. The municipalities did not provide them with any space in urban planning or the Integrated Development Plan (IDP) and Service Delivery and Budget Implementation Plan (SDBIP). These plans are defined as developing

a strategic planning instrument to inform the municipal council's planning, budgeting management and decision-making processes (RSA, 2003).

The government is bound to provide services to all citizens. But on the other hand, South Africa is not rich in water and finds it challenging to serve the informal settlements with services like water, waterborne sewage, and flush toilets. The municipality provides the services to the informal settlements may increase the inequality gap (Colvin, 2015).

According to the study by Nleya (2008), more and more people are living in informal settlements with inadequate availability of essential services. The municipality suspended the permission for the erection of shacks and sheds to stop the further development of the informal settlements. This resulted in conflicts between the municipality and the people.

Also, the need for jobs and high economic growth resulted in rapid urban migration and thus population explosion. It has further led to a huge income and financial gap between the citizens living in the informal settlements and those living in the cities. An important plan, includes the Comprehensive Housing Plan, made as part of the Development of Integrated Sustainable Human Settlements, which aims that informal settlements in South Africa should be eradicated within a short time. The benefit of this plan is that the provision of services such as water provided at all levels (townships and informal settlements) is properly ensured. Also, the Strategic Framework for water services of the Department of Water Affairs and Forestry (DWAF) states that government must ensure that water services and sanitation are made available to all levels (small, rural, urban) and that too at affordable and sustainable way. However, the income and economic gap has resulted in poverty, which makes it hard for some people to pay for water services. The government of South Africa started its plan to eliminate and upgrade the informal settlements by 2014, but they failed to achieve this goal.

Sub-Saharan Africa has accounted for most informal settlements. Globally, between 2000 and 2010, about 827.6 million inhabitants live in informal settlements (Ziblim, 2013). In South Africa, most have no facility for essential water and sanitation services, resulting in severe health problems (Musangifi, 2013). These issues had resulted in conflicts with the municipalities about illegal water connectors. But even in these situations, eThekwini Municipality has provided water services to the informal settlements through standpipes. This means the service delivery had no longer been biased or no inequalities between the different races. The democratically elected government is a people-centered government with the advantage of being a solution to the prevalent service delivery problems (Hellberg, 2014). The disadvantage is that when their expectations are not met, they resort to other means (public protests) (Malakoana, 2016).

The local community needs to get involved with the government in the decision-making processes, meeting the aim of delivering services, water, sanitation, and waste removal. With this involvement, the community accepts that it holds the policies and laws designed by the government. If people are deprived of information, they find the solution in protests and believe it is the only way the government will hear their voices. According to the study by Mchunu and Theron (2014), the state's social problems can be only solved through active citizenship and delivery of essential services such as water and sanitation; otherwise, it fails if the citizens do not play their meaningful roles.

This section provides a brief discussion on the history of South Africa, inequality in terms of providing basic services. The apartheid government included only white people into consideration in terms of planning and development and hence black people were excluded. The local government should involve all the citizens irrespective of colour, caste, location, and race. The section has also reflected on the role of providing the basic services to all equally and fairly.

1.8 RATIONALE OF THE STUDY

South Africa is a water-stressed country, experiencing a massive imbalance between the demand and the supply of water (Donnenfeld *et al*, 2018). South Africa is in great demand for water; however, the construction of dams and water transfer schemes are costly (Water Situation in South Africa, 2006). Strategists, educationalists, and environmentalists further strive to develop alternative solutions for bridging the gap between the requirement and availability of water (Saidan *et al*, 2020). Water reuse has been recognized as one of several vital strategies to achieve this delicate balance between the demand and supply of water, according to National Water Resource Strategy (NWRS) (Kemp, 2017). Recycling wastewater is considered cost-efficient as compared to other options (desalination and dam construction). In Kuwait, Alhumoud *et al*. (2010) conducted a study and found that the cost of recycling wastewater is very low compared to that of fresh water. It costs less than 0.6 KD to produce 1000 gallons of recycled wastewater than 2.75 KD to produce 1000 gallons of fresh water. Another study confirmed that the current price for tap water is ¥ 4.9/t and ¥ 2.2/t for recycled water in Tianjin (Gu *et al.,* 2015).

Also, wastewater reuse can be an important way of conserving water resources and a sustainable resolution of today's global water issues (Wester *et al.,* 2015). Many studies (Po *et al.,* 2003; Wilson and Pfaff. 2008; Alhumoud and Madzikanda, 2009; Hurlimann, 2010; Dolnicar *et al.,* 2011; Velasquez and Yanful, 2015) have investigated water reuse and found public acceptance as the primary challenge for implementing reuse projects. However, there is noticeable resistance from some societies to approve recycled water for potable use. The success of this strategy of wastewater treatment plants will largely

depend on the general public's willingness to accept the water reuse for different purposes; however, the negative public opinion has been recognized as a significant issue in considering these water reuse schemes. Therefore, this study identifies the public perception towards the acceptability of wastewater reuse and evaluates the issues and strategies for its application.

1.9 RESEARCH PROBLEM

International Standards have identified South Africa as a water-stressed country. The world's average annual rainfall is 860 mm, and that of South Africa is 464 mm, which receives about half of the world's average rainfall. Only one-third of South Africa's major rivers are in moderate conditions, with more than 60% of rivers being overexploited (Donnenfeld *et al.,* 2018). Durban is the largest populated city in KwaZulu-Natal South Africa. Since July 2016, the coastal areas had faced severe threats of drought in (2015-2017) as the water storage level in three significant dams, viz. Albert Falls Dam, Nagle Dam and Inanda Dam supplying water resources were 46%, 46% and 68%, respectively, compared to the satisfactory storage level of 70%. As a result, 15-50% water restrictions (15% for domestic and industrial use and 50% for agriculture) were imposed to alleviate the problems of drought and were removed in 2019. Although groundwater may play an important role for water supply, however such resources are limited and using them sustainably is an issue (Blignaut and Heerden, 2009). The Department of Water and Sanitation (DWS) in the National Water Resources Strategy 2 (2016) has identified water reuse as a priority.

The current drought situations highlight increasing demands, which necessitate advanced solutions to the water supply problem; recycling has been recognized by the Department of Water and Sanitation (DWS) in Durban. Umgeni Water and DWS installed a few wastewater reuse projects to demonstrate and evaluate technical feasibility. The current projects include the construction of 2 megalitres per day (ML/day) reclamation plant as part of the Darvill Wastewater Treatment Works (WWTWs) upgrade. Two seawater desalination plants (150 ML/day each) were constructed at Tongaat (north of Durban) and Lovu River Estuary (south of Durban). Additionally, a remix plant (6.25 ML/day) combining wastewater reuse and desalination was constructed in South Durban, Bluff.

Technical feasibility and public acceptance are necessary to execute the reclamation project successfully (Po *et al.*, 2003). Therefore, it is essential to study the public perception of the acceptance of recycled water to make the current demonstration projects successful in Durban. The acceptance or rejection of water reuse depends upon various factors. The public usually favours reclamation initiatives but is hesitant to consume or ingest recycled water. For wastewater reuse initiatives to be successful, public acceptance is crucial and thus can be achieved by overcoming negative perceptions of the

public on wastewater reuse. The work aims to study the public perception of recycled water and identify solutions and strategies to increase public acceptance.

Perception

Perception is defined as one's capability to understand and comprehend things that are not noticeable to other people, as the Cambridge Dictionary describes. However, Dowler *et al*. (2006) define public perception as the information gathered from a public opinion survey. Public opinion is the aggregate view of a group of people. However, studying public perceptions is imperative as they may change over time due to many factors. The perception accessed at one time and from one individual may vary over time and in other contexts. Factors such as beliefs, knowledge, social and cultural determinants are responsible for the perception. One of the most influential social-psychological models for describing human behavior is the theory of planned behavior (TPB) (Armitage and Conner, 2001). Fishbein and Ajezen (1975) developed the theory of planned behaviour.

1.10 AIM AND RESEARCH GAP

The study's main aim was to assess the public perception of recycled water and to identify strategies further to increase public acceptance.

Wastewater reuse is now evolving as one of the vital sources of quality water for many countries. However, it requires massive investment in technology, process modification and mostly acceptance from the public. Much research has been done globally on the perception and acceptability of wastewater reuse in Australia, China, Israel, and America (Dolnicar *et al*., 2009; Gu *et al.,* 2015; Velasquez and Yanful, 2015; Wester *et al.,* 2015; Gracia-Cuerva, 2016). So far, no research has been conducted about the public perceptions of recycled wastewater reuse based on racial groups. The study focuses on identifying the factors affecting the public acceptability of water reuse to achieve sustainability and a better understanding of public acceptance to develop strategies. No empirical research has been conducted in South Africa confirming the acceptance of wastewater reuse for portable uses. However, this work was undertaken to identify the underlying factors that predict the intention to accept wastewater reuse for non-potable uses (Adewumi *et al.,* 2014). Some factors like subjective norm and physical quality satisfaction could not be measured because the scales formed were unreliable. Therefore, an effort was being made to identify and measure the factors that predict the intention to accept wastewater reuse in the city of Durban, South Africa.

1.11 RESEARCH OBJECTIVES

- to evaluate significant factors affecting the public perception and acceptability of recycled wastewater,
- to evaluate socio demographic variables including gender, age, education, religion, marital status, and income level on the willingness to use and participate in a reuse plan,
- to assess the role of knowledge on public acceptance of the recycled water and
- to develop a model system to understand the behavior of the public towards the reuse of wastewater.

1.12 HYPOTHESES

In consonance with the above-stated objectives, the following hypotheses are:

H1: Respondent's trust in the wastewater authorities positively affects the attitude to accept the wastewater reuse.

H2: Past experience from the service providers positively impacts the attitude.

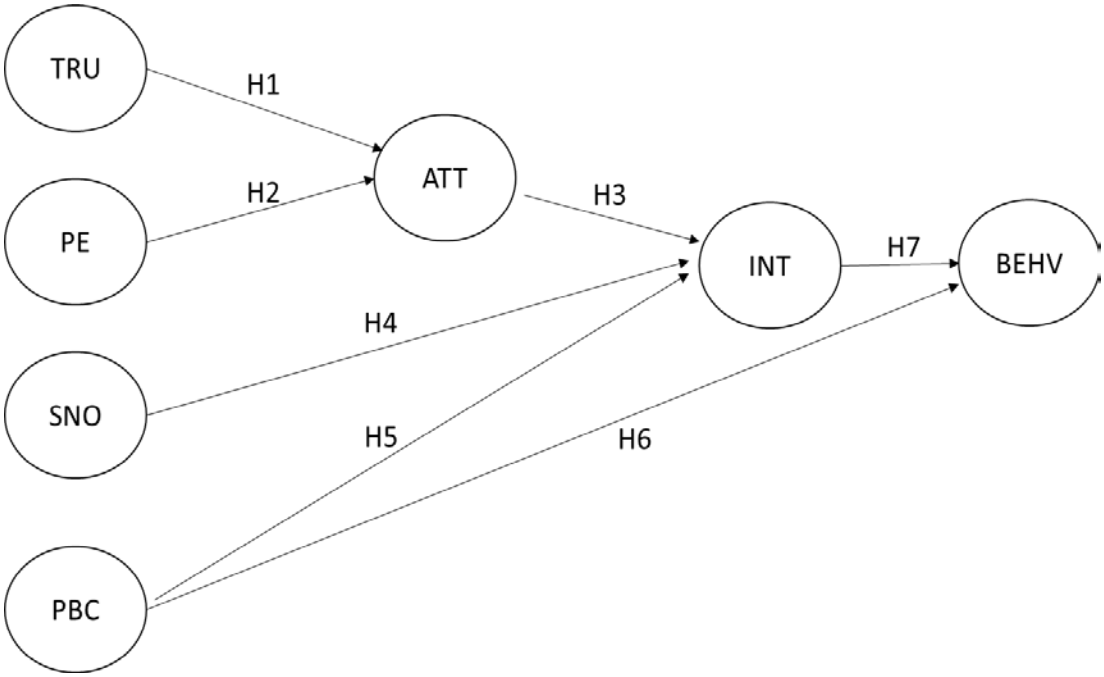
H3: Respondent's positive attitude towards wastewater reuse significantly influences the intention to accept the wastewater reuse.

H4: Higher subjective norms associated with wastewater reuse positively impact the intention to accept wastewater reuse.

H5: Respondent's perceived control over the water source and its application significantly influence the intention to accept wastewater reuse.

H6: Respondent's perceived control over the source of water and its application has a positive and significant influence on the behavior to accept the wastewater reuse.

H7: Intention has a positive and significant effect on the behavior to accept wastewater reuse.



1.13 DEFINITIONS OF TERMINOLOGY/WORDS SPECIFIC TO RECYCLED WATER

1.13.1 Wastewater

Wastewater is the water obtained after the use of fresh water or raw water in a variety of applications like, cleaning, washing, irrigation, or industrial purposes. It contains residual contaminants associated with the use of water. According to Corcoran *et al*. (2010), wastewater is denoted as the sewage comprising of black water (excreta) and grey water (from kitchen and bathing), water from commercial organisations, industries, stormwater, effluents from agriculture, horticulture, and aquaculture. Therefore, wastewater is the water from any of the above combinations; domestic, industrial, commercial, or agricultural activities.

1.13.2 Grey Water

Wastewater is obtained from the household use of water like washing, laundry, cleaning, and bathing. This type of wastewater is free from faecal matter.

It is also called sullage, generated from the households except for the toilets. It is simpler to treat and reuse this water as it contains fewer pathogens and contaminations than other types of wastewaters. People can use the grey water for toilet flushing, irrigation, parks, cleaning, and other non-potable activities. The advantages of reusing the grey water can be lessening the need for fresh, clean water and reducing the wastewater for treatment which is quite costly (Duttle, 1990).

1.13.3 Black Water

The wastewater is derived from the toilets and urinals, containing faecal matter. Black water may contain faeces and urine from toilets and thus has many pathogens.

The water from the bathtubs, showers and washing machines is grey water. Before releasing into the environment, it must be putrefied as it contains many pathogens (Tilley *et al*, 2014).

1.13.4 Wastewater Treatment

Around the world, approximately 80% of wastewater is not treated and is discharged directly into the environment (WWAP, 2017). This causes a widespread problem known as water pollution. It is very important to treat the wastewater to avoid the depletion of the environment. Depending on the type of contaminants, the different processes used to treat the wastewater in the wastewater treatment plants are physical, chemical, and biological (Tchobanoglous *et al*, 2003).

1.13.5 Treatment Processes

Grey water is simpler to treat and reuse than sewage for a fewer number of pathogens and contaminations. The treatment of grey water works on the principle of source separation; thus, grey water is kept separate from the toilet wastewater containing a massive load of pathogens. Grey water is usually higher in organic matter, and coming from kitchens contains fats, oils, and grease. So, before discharging into a grey water tank, it must undergo the primary treatment to remove these substances. Grey water can be easily recycled within the home, but drinking it is never safe. People can use it for irrigation. Furthermore, various treatment steps are required for toilet flushing and washing. The treatment processes include two systems: Biological systems and Mechanical systems (Tilley, 2014).

Biological systems include the construction of wetlands or living walls and bioreactors or membrane bioreactors.

The plants in the constructed wetlands use effluents of grey water as nutrition for their growth. Mechanical systems include sand filtration and systems based on UV radiation (Tilley, 2014).

1.13.6 Wastewater Reuse

Use recycled wastewater for an activity other than the one that created it. It must involve the transformation of the user—for example, the recycling of municipal wastewater for agricultural irrigation.

1.13.7 Direct Reuse

Is recycling of treated wastewater by directly transporting it from the place it is created to a different location for another use.

1.13.8 Indirect Reuse

Recycling of treated wastewater after it has been discharged into surface water and from which the recycled wastewater is used for other purposes.

1.14 CONCLUSION

This chapter presents the background and overview of the study. Global scenario of recycling of wastewater and Sustainable Development Goals are mentioned in this chapter. Legislation, policies, and guidelines for recycling wastewater in South Africa have been also discussed. South African History and Water Service Delivery Issues in eThekwini Municipality are also briefly discussed. The chapter focused on rationale, need, aim and objectives of the research topic. It also highlights the hypothesis of the study.

1.15 STRUCTURE OF THE THESIS AND CHAPTER OUTLINE

- **Chapter 1 Introduction**

  This chapter presents the background of the study. It offers a description of the concept of recycled wastewater reuse and perception. It focuses on rationale, need, aim and objectives of the research topic. It also highlights the global scenario of recycling of wastewater and SDGs. Policies and guidelines in South Africa for recycling wastewater are also discussed.

- **Chapter 2 Literature Review**

  This section provides the secondary data such as articles from books, scientific journals, websites etc. It provides the national and international work being done. It also consists of review of past studies related to public acceptance of wastewater reuse and with the literature of the various variables involved to measure the public perceptions towards the acceptability of recycled wastewater usage.

- **Chapter 3 Research methodology**

  This chapter presents the methodology used in this study including the sample size, design of questionnaire, sample design and data collection methods. In addition, this chapter explains the various techniques and tools used to analyze the collected data.

- **Chapter 4 Analysis and Interpretation**

  This chapter provides the demographic statistics and the results from other techniques. This chapter brings the interpretation of the results after using Confirmatory Factor Analysis and Structural Equational Modelling.

- **Chapter 5 Conclusion and recommendations**

  This section presents the summary of the work, findings, conclusion and suggestions, and recommendations for future research.

  The next chapter provides a review of related literature on wastewater reuse acceptability and public perception.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter scholarly work on recycling of wastewater and public perception are reviewed. Various behavioural theories are discussed. Recycling of wastewater at global level and in South Africa is also explored. The literature review focused on the review of past studies related to public acceptance of wastewater reuse and with the literature of the various variables involved to measure the public perceptions towards the acceptability of recycled wastewater usage. Conceptual and analytical framework are briefly explained in this chapter.

There are limited freshwater resources mainly due to overexploitation. The water authorities are indulged in developing various alternative supply of water. Recycling of water has been identified as a sustainable strategy to meet the deficiency and maintain the environment (Saidan *et al.*, 2020). Therefore, it constitutes an essential part of integrated water resource management. However, implementation has become a serious debate among the communities and societies. The public resists recycled water due to social perceptions (Wilson and Pfaff., 2008).

Most of South Africa, especially parts of the Northern and Western Cape provinces, are drought prone. The main reasons for water scarcity are the semi-arid climate, growing urban development, and increasing pollution. These increasing droughts, higher temperatures and decreasing glaciers will have social, economic, and environmental impacts on the population (Morrison *et al.,* 2009). This section aims to highlight the global and local literature on barriers to recycling wastewater for direct potable applications. The main focal themes covered in this chapter are drivers for wastewater recycling, legislation for wastewater recycling, public perception of recycled wastewater, and the relevance of South African history to service delivery. Finally, various frameworks to study public perception towards recycled wastewater usage in households were critically reviewed.

2.2 WASTEWATER RECYCLING AROUND GLOBE

Globally, Namibia, the United States (US), and Singapore have successfully implemented wastewater reuse projects (Tortajada, 2020). The reclaimed wastewater project of Goreangab in Namibia has been a good model for

experts to learn practical solutions for implementing wastewater reuse. This plant meets around 24% of the city's drinking water supply. In 2014-2016, it helped to deal with drought, where local water reservoirs provided only 10% of drinking water (Van Rensburg, 2016). The largest wastewater reuse plant in the world, located in Orange County, California, United States (US), produces 379000 cubic meters of drinking water per day. There are over 230 operational wastewater reuse projects in the US, and the water is used for irrigation and parks, school grounds, landscaping, and industrial uses. Researchers have attributed its success to public engagement and awareness campaigns, which the Orange County Water District adopted from the start of the project in 2008 (Tortajada and Van Rensburg, 2020). In Singapore, the most effective reclaimed water project, NEWater, is an excellent example of wastewater reuse. It recycles the wastewater and is regarded as the best and cheaper option (Po *et al.,* 2003). NEWater is currently contributing to 40% of Singapore's drinkable and non-drinkable water demand, with a target of 55% by 2060. Transparent communication between policymakers, public and technical managers has been reported as a key driver of its success (Tortajada and Nambiar, 2019).

Among developing countries, China, almost 924 reclaimed wastewater treatment plants have been constructed, which supply the reclaimed water for industrial, agricultural and landscape applications (Zhu *et al.,* 2018). Jordan is a successful example with strong community acceptability, achieved through proper education of its citizens about water scarcity and the significance of wastewater reuse in agriculture (Al-Momani and Rasheed, 2016). South Africa started a wastewater recycling plant in 2010 in Durban with a 45000 cubic metres capacity.

The public acceptance of reclaimed wastewater for drinking is lower than other direct potable applications (figure 2.1). The acceptance rate is reported as 5-42% (average of 15 countries as 28%), with a minimum reported in Kuwait (5%) and a maximum reported in Canada (42%) (Alhumoud and Madzikanda, 2009; Velasquez and Yanful, 2015). The order of acceptability was toilet flushing (87%)> landscape irrigation (86%)>cleaning (80%)>bathing (55%)>drinking (28%). Velasquez and Yanful (2015) reported an increase in acceptability of direct contact reuse applications (drinking and cooking) from 42 to 76% and from 51 to 80%, respectively when the participants were asked to consider drought conditions. This indicates that the knowledge of water scarcity can effectively increase the acceptance of reclaimed wastewater in direct contact applications. The studies from developed countries indicate that the public opposition to using recycled wastewater for drinking is not confined

to developing countries. Rather, developed nations still have this challenge. Among non-potable uses, toilet flushing, and landscape irrigation are the most favorable (Figure 2.1). In irrigation types, landscape irrigation is more acceptable than agriculture irrigation. Buyukkamaci and Alkan (2013) reported a 55% and 50% acceptance rate for landscape and agricultural irrigation in Turkey. Chen *et al*. (2015) reported 94% and 82% acceptance rates for landscape and agricultural irrigation in China. Velasquez and Yanful (2015) reported a 90% and 73% acceptance rate for landscape and agricultural irrigation in Canada.

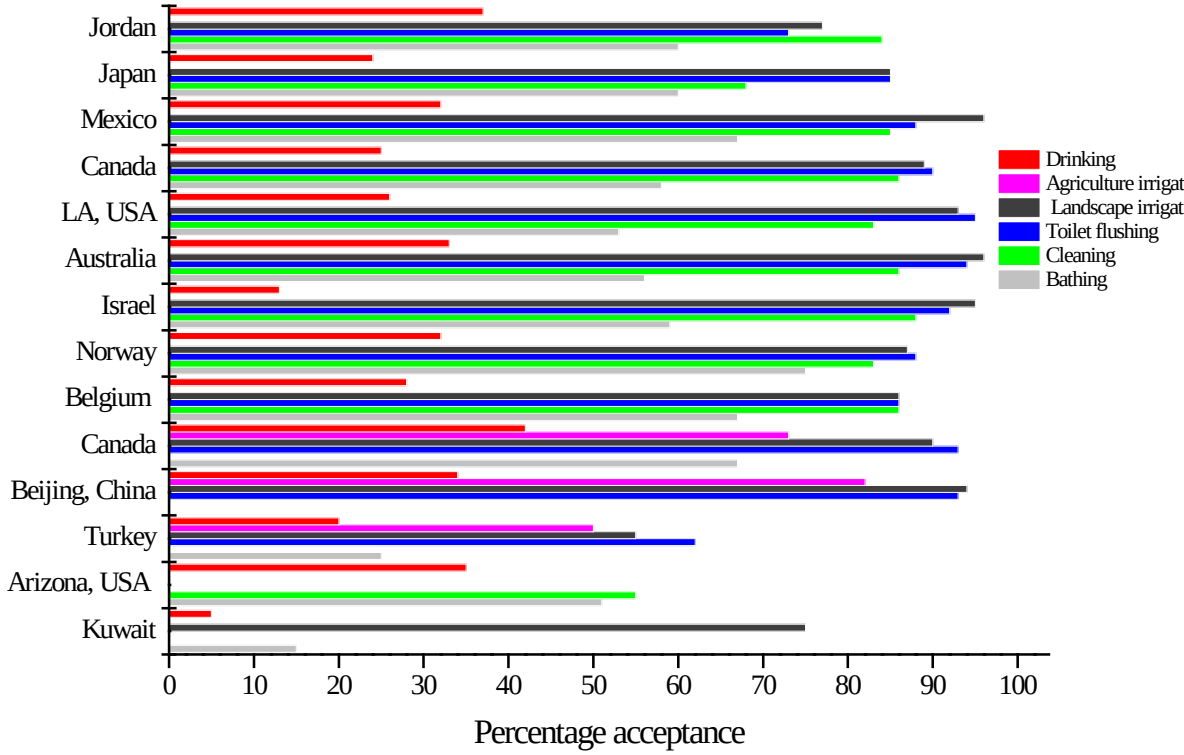


Figure 2. 1 Comparison of acceptance of reclaimed water for drinking purposes and other direct portable applications, from different countries across world.

2.3 DRIVERS OF WASTEWATER RECYCLING

The drivers or factors for wastewater recycling may vary from one country to another, depending on the water management scenario. The rapid population, uneven distribution of water resources, and groundwater pollution are some common drivers for wastewater recycling (Jhansi & Mishra, 2013; Cain, 2011; EIB, 2008). According to Cain (2011), high demand for water by increasing population and agricultural irrigation, the uneven distributional pattern of rainfall and water scarcity are the

motivational factor for wastewater recycling. In Australia, Po *et al*. (2003) studied the various reasons for introducing wastewater recycling. Some of the reported drivers for wastewater recycling in Australia include the prediction of more droughts in future, non-conservation approaches from the public, demand for a higher quality of water for daily uses and increased public awareness about the benefits of recycling wastewater.

Many studies have been reported to identify the drivers for recycling wastewater and against it (resisting factors), which are tabulated in table 2.1. Among the social drivers, the favourable driver for wastewater recycling is the population pressure, and the opposition driver is the public acceptance (Chanan *et al.,* 2011; Hurlimann & Dolnicar, 2010). The economic driver for recycling wastewater is water price security, and the challenge is its higher cost than other alternatives. Another factor, which drives wastewater recycling, is sustainability in the water sector (Giurco *et al.,* 2011). The technical factors driving wastewater recycling are ageing water infrastructure that needs up-gradation (Chanan *et al.,* 2011; Giurco *et al.,* 2011). According to Anderson (2006), there is one more factor called natural factor: drought and water scarcity are the drivers of wastewater recycling.

Table 2. 1 Overview of past studies related to public perception of recycled wastewater.

S. No.	Author	Research Design	Location of the study	Factors/ Objectives	Findings
1	West *et al*. (2017)	Survey method	Australia	To understand effect of critical risk on recycled water schemes	Political, regulatory, organisational, and financial factors were considered as critical risks
2	Goodwin *et al*. (2018)	Survey method, random sampling	London, UK	To understand different forms and mechanisms of communication with the public around reuse.	use of video animations to communicate the safety of non-potable recycled water schemes
3	Massoud *et al*. (2018)	Survey method	Administrative Beirut Area (ABA)	To study the effect of Trust, risk, disgust factor and religious beliefs on wastewater reuse.	Degree of human contact is indirectly related with the wastewater reuse and its acceptance; also, religious beliefs were found significant with the acceptance level.
4	Adewumi *et al*. (2010)	Review	South Africa	To study the effect of aridity, quantity of reuse, tariffs, source quality, public health, willingness, public trust and knowledge, and regulations and guidelines for reuse.	overview of water resources situation and wastewater
5	Wilson and Pfaff. (2008)	literature review, email survey, interviews, and focus group discussion.	Durban, South Africa	To study religious or philosophical objections to the potable reuse of wastewater	No religious restrictions were found with the acceptance of wastewater reuse either locally or internationally, but people are generally not comfortable with the idea of potable reuse
6	Cuerva, (2016)	Survey method	USA	To study the influence of climate, demographic variables, and financial incentives on wastewater reuse.	Ethnicity, education level, and income, financial incentives and decrease in the monthly water bills
7	Adewumi, (2014)	Survey method, Questionnaires	Limpopo Province, South Africa	To study the factors, like, trust, attitudes and control towards intention to accept and behaviour towards wastewater reuse.	Intention as important to accept or reject the wastewater reuse

8	Velasquez and Yanful. (2015)	Online survey	Canada	To study the effect of trust, knowledge, personal contact, risk and alternate uses on wastewater reuse	Accept the wastewater reuse that do not involve drinking or close personal contact
9	Peters and Goberdhan. (2016)	Survey method, unstructured questionnaires and interviews	Trinidad, Carribean	To understand the effect of trust, knowledge, health risk, and uses on treated wastewater reuse	Accepted wastewater reuse for non-potable uses.
10	Bakopoulou & Kungolos. (2009)	Personal interviews	Thessaly region, Greece	To study the farmers willingness for irrigation & consumers' willingness to accept these agricultural products	Farmers will accept during water shortages and Consumers will accept if provided with adequate information
11	Fielding and Roiko. (2014)	Survey method	Australia	To understand knowledge about the wastewater reuse (basic information, information about the pollutants & information about the chemicals used)	Information is directly related to the greater knowledge and thereby, increases the acceptance level.
12	Gu *et al*. (2015)	Survey method	Tianjin, China	public knowledge, perceptions, and attitudes toward reclaimed wastewater	higher education and income levels are positively related to wastewater reuse and are more willing to pay for it
13	Wester *et al*. (2015)	Survey method	US	To study the underlying factors for the discomfort of accepting the wastewater reuse	female, having less education, and being particularly sensitive to pathogen-related disgust stimuli
14	Dolnicar *et al*. (2009)	Survey method	Australia	To study the effect of information on public acceptance	information about water from alternative sources increases public acceptance
15	Garcia and Pargament. (2015)	Review	Israel	to analyse the economic, social and environmental aspects surrounding the concept of wastewater reuse	To help decision-makers In evaluating the success with respect to Integrated Water Resources Management in economic terms.
16	Lyu *et al*. (2015)	Review	China	wastewater reuse practices in China, and its opportunities and challenges	Regulations for wastewater reuse programs, encouraging public awareness and cooperation among stakeholders.

2.4 WASTEWATER RECYCLING IN SOUTH AFRICA

The recycled wastewater in South Africa can be used for agricultural, industrial, and domestic purposes. Recycled wastewater can be used in the following sectors.

2.4.1 Agriculture

The agricultural sector accounts for approximately 60% of total water use in South Africa (7680 million m3 per annum). For the water scarce country like South Africa, wastewater has been identified as an alternative source for agriculture (being the largest user). The province KwaZulu Natal is the highest contributor to South Africa's GDP (Saldias *et al.*, 2016). Only a small portion of recycled wastewater is directly used for irrigation in agriculture. The potential benefits of using wastewater reuse for agriculture are, the constant, reliable source, and high nutritional content present in it (Saldias *et al.*, 2016). Israel aims to recycle all its domestic wastewater for agricultural purposes (Icekson *et al.*, 2003). Therefore, there is a great scope for expanding the use of recycled wastewater for agricultural uses in South Africa. The various advantages are job creation, labour-intensive agriculture, and freshwater for other services (Lefore, 2019).

2.4.2 Municipal Uses (Non-potable water)

The wastewater from municipal wastewater treatment is the primary source of recycled wastewater in the urban areas (Yildiz, 2012). The recycled wastewater from municipal works is used to irrigate parks, fields (sports), golf courses and industrial purposes (cooling). The recycled wastewater can be used for many other applications like firefighting, toilet flushing, street cleaning and other non-potable uses (Dolnicar and Shafer, 2006).

2.4.3 Municipal Uses (potable water)

After meeting all the quality standards, recycled wastewater can be used for domestic purposes. The recycled wastewater can be directly supplied to households for various uses, or it can be discharged back to the freshwater resources where it mixes with other water and then is again treated and distributed (indirect reuse). Most of the potable wastewater reuse schemes worldwide are based on indirect reuse. Direct wastewater reuse is still in its infancy but has been successfully implemented in countries like Namibia and Singapore (Wilson and Pfaff, 2007).

2.4.4 Industries

The industries do not need pure and clean water to process their activities and thus can use municipal recycled wastewater. The recycled wastewater from an upstream user can be used for various industrial purposes. Industries can work on Zero effluent discharge (ZED), but it needs high standard treatment to make wastewater fit for direct potable use (Niekerk and Schneider, 2013).

2.4.5 Mining Sector

Mining and mineral processing use vast amounts of water for various applications. Acid mine drainage can be a potential water source for mining applications. A typical application of recycled water will be to collect acid mine drainage and reuse it for mine applications to replace freshwater intake. The recycled wastewater can be widely used in the mining sector as it can help meet environmental requirements and reduce water costs (Lane *et al.*, 2014).

2.4.6 Environmental Needs

Water is essential for both natural and artificial ecosystems. It is vital to have a proper flow in streams, rivers, estuaries, and wetlands and maintain the appropriate water levels in artificial ecosystems like urban lakes and dams. Recycled wastewater can play a significant role in supporting this by supplementing or substituting fresh water. However, it is vital to ensure that the quality of recycled wastewater should not deteriorate the existing water quality (Adewumi *et al.*, 2010; Saldias *et al.*, 2016).

2.5 DRIVERS OF WASTEWATER RECYCLING IN SOUTH AFRICA

South Africa is known as a water-stressed country. Several factors are responsible for the decreased quality of natural water resources. These include the growing human population, pollution, deterioration of river catchments, urbanization, deforestation, damming of rivers, industry, agriculture and accidental water pollution. South Africa is in great demand for water; however, the construction of dams and water transfer schemes are costly (Water Situation in South Africa, 2006). The negative effect of a dry climate on water resources has resulted in a significant readiness to reuse wastewater. Adewumi *et al*. (2010) reported that 48% of the respondents in the provinces of South Africa agreed that arid climatic conditions have resulted in the need for wastewater recycling. The droughts, growing population, water balance, environmental pollution, increasing discharge of wastewater, reduction in the water resources, the cost of alternative options and water restrictions were identified as some of the drivers of wastewater recycling. Drawing on these findings, the research establishes that drivers for water reclamation in South Africa fall within the five main categories: natural, human-induced, institutional/technical, and economic factors.

2.6 WASTEWATER RECYCLING IN ETHEKWINI MUNICIPALITY, SOUTH AFRICA

EThekwini Municipality is the third-largest municipality in KwaZulu-Natal. South Africa. Durban is a coastal city in South Africa which had recently experienced a severe drought invasion from 2015 to 2017. The water storage level in the main dams viz. Albert Falls Dam, Nagle Dam and Inanda Dam were 46%, 46% and 68%, respectively (as of 25 July 2016), compared to satisfactorily storage of 70%. Although groundwater may play an essential role in water supply, such resources are limited and using them sustainably is an issue (Blignaut and Heerden, 2009). The Department of Water and Sanitation (DWS) in the National Water Resources Strategy 2 (2016) have identified water reuse as a priority solution to growing water scarcity. Water utilities of KwaZulu-Natal (viz. Umgeni Water and eThekwini) initiated reclamation projects of wastewater reuse, desalination, and combined desalination with wastewater reuse to cope with the water scarcity in South Africa.

EThekwini Water and Sanitation department and Umgeni water have started wastewater recycling projects, which are implemented to increase the water supply in Durban. Umgeni Water completed a feasibility study of two seawater desalination plants (150ML/day). The sites for implementation are based in Tongaat (north of Durban) and at the Love River Estuary (south of Durban). Another desalination plant of 10 ML/day capacity is based at Elysium, KwaZulu-Natal, in the South Coast region of KZN and is currently under investigation. The

aim of this desalination plant is twofold. First, to augment the water supply and second, to develop the capacity/know-how of Umgeni staff in the desalination field.

A 2 ML/day wastewater reuse treatment project by Umgeni water is currently under construction at Darvill WWTW, Pietermaritzburg, for a feasibility study. The purpose is to generate water, which can augment the water supply along the western corridor of the eThekwini Municipality. The advantage of the wastewater reuse treatment project is that water is available at higher levels and can be supplied using gravity. The alternative is costly due to water pumping and water transfer from Durban Heights WWTW to serve these demand centres. Fifty per cent of the final effluent wastewater from this reclamation plant before tertiary treatment will be used as wash water in the main plant for high-pressure cleaning, and the remaining portion will undergo tertiary treatment to produce drinking water.

The Remix Water project is located in Bluff, Durban South. The treated water will be used for drinking and other conventional purposes. Currently, the total capacity of the demonstration treatment plant is 6.25 ML/day; however, upon successful implementation; the plant will be upgraded to a capacity of 100 ML/ day, whereby 50 ML/day will be supplied to the central city and 50 ML/day to the South of Durban.

2.7 PUBLIC PERCEPTION

According to Kotler and Armstrong (2014), perception is the process by which people select, organise, and interpret information to form a meaningful picture of the world. Perception consists of three stages: sensation, information selection and interpretation (de Chernatony *et al.,* 2011). The sensation is any five senses' response (eyes, ears, mouth, nose, and touch). It refers to the immediate reaction of the senses to a stimulus, e.g., a brand name or an advertisement. The process of perceiving starts when the senses pick up stimuli and attention is allocated to the sensation (Solomon *et al.,* 2006). Then the response and meaning are given to the information, and finally, the interpretation occurs. Perception is defined as one's capability to recognise and understand things that are not noticeable to others, as the Cambridge Dictionary describes. However, Dowler *et al*. (2006) defines public perception as the information gathered from a public opinion survey. Public opinion is the aggregate view of a group of people. However, studying public perceptions is imperative as they may change over time due to many factors. The perception accessed at one time and from one individual may vary over time and in other contexts. Factors such as beliefs, knowledge, social and cultural determinants are responsible for the perception.

2.8. FACTORS INFLUENCING PUBLIC ACCEPTANCE OF RECYCLED WASTEWATER

The perception of wastewater reuse is influenced by several factors such as emotions, risk, trust in service providers and cost of produced water, which may influence the decision-making processes. Hence, there is a need to identify significant factors which can influence the public perception and decision-making of accepting or rejecting water reuse. Factors that can influence the perception of wastewater reuse after going through the literature are summarised below.

2.8.1 Emotions / Disgust / Yuck Factor

Since the early 1970s, the "yuck factor" or "disgust" factor can be regarded as a severe challenge for accepting recycled water. The public considers the use of recycled water a psychological barrier, which appears to be the disgust emotion resulting from the thought of reusing wastewater. Some participants are willing to use recycled water for all their activities, including drinking water. However, at the same time, they also confessed that they would choose to drink bottled water or pass their household drinking water through a filter (Po *et al.,* 2003). The public had associated recycled water with waste and portrayed a mental image of "disgust". The "disgust emotion" refers to emotional discomfort generated from close contact with unpleasant stimuli. Thus, a disgust reaction is generated as people perceive recycled water as unclean or unpleasant. Therefore, current projects avoided terms such as "treated wastewater". For example, recycled water is termed "NEWater" in Singapore and "Repurified water" in San Diego (Leovy, 1997).

2.8.2 Risk Factor

The perception of risks with recycled water plays an essential role in deciding on water reuse for the public (Hartley, 2006). The primary concern of recycled water is the associated health risk after consumption. The level of public acceptance may increase if the water quality complies with international standards (Hartley, 2006; Rivett *et al.,* 2013). The influence of the risk factors on public acceptance of reclaimed water was reported in the literature. A survey by Sydney Water (1999) regarding a water reuse scheme found that 59% of respondents agreed with the statement that 'no one could guarantee the safety of recycled water. Some studies reported significant relationships between risk perceptions and trust in the institutions and organisations. Studies have shown that higher levels of trust are related to the lower perceptions of risk and that, in turn, can increase public acceptance (Nancarrow *et al.,* 2009; Ross *et al.,* 2014). Therefore, suggesting that acceptance level, risk and trust should have an indirect relation.

Eiser *et al*. (2002) reported two ways to link trust and risk perceptions (causal-chain and associationist view). According to the causal-chain view, factors such as Trust and risk are interrelated in any decision-making. In other words, Trust depends upon how people process and interpret risk-related information about the technology. This may assist in shaping the decision to accept or decline the

technology. Whereas an associationist view holds that both trust and risk perceptions are independent, meaning the acceptance of technology can be determined by both underlying attitudes of trust and risk perceptions. The associationist model was strongly supported in contrast to the causal model (Eiser *et al.,* 2002). Various studies have found that trust is a consequence of attitudes rather than the driver for acceptance (Frewer *et al.,* 2003). Moreover, in the case of water reuse, the associationist model plays a significant role, as trust and risk perceptions play individual roles. Therefore, trust, risk and emotional reaction can be strong predictors in deciding the behaviour of the public for water reuse.

2.8.3 Trust in Service Provider

Trust can be described as a multidimensional and complex construct and an emotional state that includes the intention to accept vulnerability based upon positive expectations of the behaviour of the authority responsible for recycled water schemes (Fischoff 1999; Siegrist *et al.,* 2000). According to Siegrist *et al*. (2000), many individuals make decisions based on scientific research; however, they lack resources such as knowledge, time, and interest. Therefore, they rely on trust from authorities and government agencies to make decisions. Hurlimann *et al*. (2008) investigated the role of trust in public acceptance of potable water reuse. The past research and theory also provide a solid basis for the hypothesis that higher trust in water authorities to deliver safe recycled water will be related to lower risk perceptions, thus leading to the greater acceptance of recycled water.

2.8.4 Social Set-Up

Social and geographic factors influence the acceptance of recycled water. (Po *et al*., 2003). However, according to the study of Jeffrey and Jefferson (2003), there is no significant relationship between recycled water acceptance and socio-demographics. Acceptability for water reuse has shown a high correlation between men and those with higher levels of education (Dolnicar and Hurlimann, 2009). In other studies, the age of participants was also related to public acceptance (Dolnicar and Hurlimann, 2010; Dolnicar *et al.,* 2011). Hence, socio-demographics is essential in selecting a representative sample for the survey.

2.8.5 End Use

The final usage of recycled water can impact public acceptance.

Acceptance is generally higher when there is minimal human contact (Hartley, 2006), leading to a higher acceptance of using recycled water for industrial applications (Po *et al.,* 2003). This was further supported by Dolnicar *et al*. (2011), whereby 92% of respondents agreed they would use recycled water for irrigation. However, only 36% confirmed drinking water.

2.8.6 Cost

The cost factor can increase or decrease public acceptance of reclaimed water. Cheaper drinking water sources can increase their willingness to purchase and consume. No change in tariff can shift public emotions to other factors such as disgust, leading to lower acceptance of recycled water. Hartley (2006) reported that public acceptance of water reuse is higher when network installation and running costs are reasonable. However, the cost factor depends on various parameters, and its value is attached to capital investments made by the service provider and returns (Woolston and Jaffer, 2005).

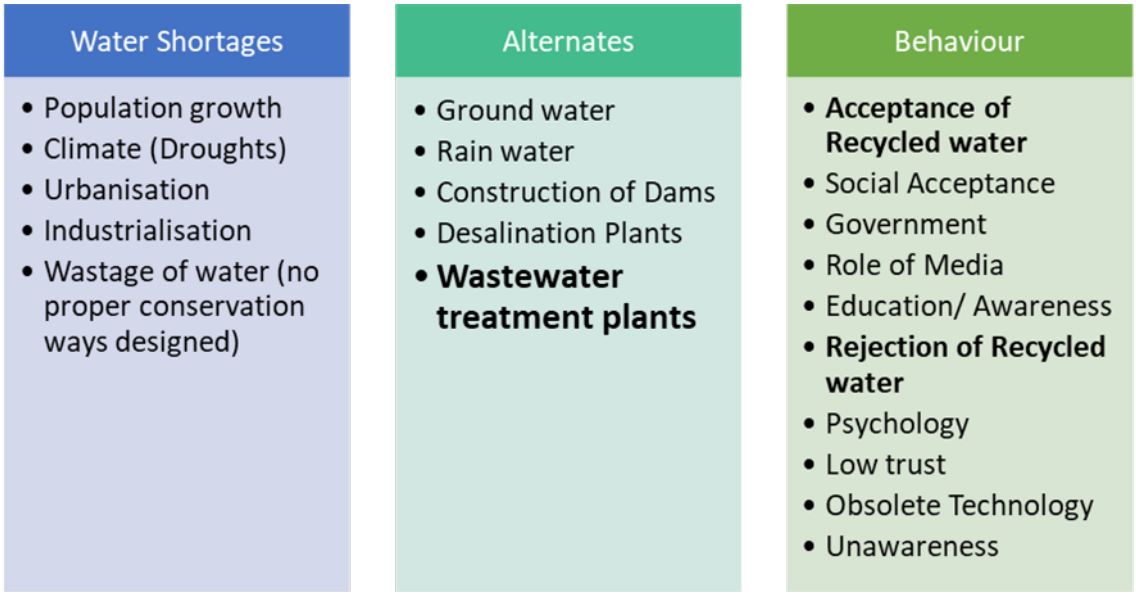


Figure 2. 2 Graphical representation of literature review

Source: Author's Compilation

2.9 THEORIES FOR UNDERSTANDING PUBLIC PERCEPTION

The behaviour or the decision making to accept or reject the specific product depends upon various factors like environmental, personal, and behavioral characteristics. The different theories try to clarify why behaviour changes. The behavioral theories have been applied in health, education, and criminology to understand behavioral change for improving the services offered. The most prevalent behavioral theories are classified as Theories of individual behaviour and behaviour change and Social and Technological theories of conduct and behaviour change. Further classification of the behavioral theories is as described below:

Theories of individual behaviour and behaviour change

· The Theory of Planned Behaviour and Theory of Reasoned Action

· The Health Belief Model

· Trans-theoretical Model

Social and Technological theories of behaviour and behaviour change

· Social Cognitive Theory

· Social Practice Theory

· Diffusion of Innovation Theory

These theories are relevant to understanding the public's perception of acceptance of recycled wastewater and are explained in subsequent sections. Theories of individual behaviour and behaviour change

- The Theory of Planned Behaviour and Theory of Reasoned Action
- The Health Belief Model
- Trans-theoretical Model

Social and Technological theories of behaviour and behaviour change

- Social Cognitive Theory
- Social Practice Theory
- Diffusion of Innovation Theory

These theories are relevant to understand perception of public towards acceptance of recycled wastewater and explained in subsequent sections.

2.9.1 Theory of Reasoned Action and Theory of Planned Behaviour

According to the theory of reasoned action, intention is a key factor in determining behaviour. Intention acts as an agent of conduct and is the consequence of the sum of attitudes towards a behaviour. The positive or negative intentions from the personal attitudes and the social pressures (subjective norms) shape the desired behavior (Fishbein and Ajzen, 1975). Ajzen 1985 formulated the theory of planned behaviour by expanding the idea of reasoned action. According to this theory, the individual attitudes and beliefs explain the behaviour. The approach added the third set of factors as perceived behavioral control. This is like self-efficacy, which means the perceived ease or difficulty with which the individual will be able to achieve the behavior. Strong correlations have been found between behavior and attitudes and perceived behavioral control components. This theory is used to explain and predict the likely behavior but is not considered helpful in planning and designing the behaviour intervention type (Taylor *et al.,* 2007; Webb *et al.,* 2010). The various limitations of the theory of Planned Behaviour are, it does not consider environmental or economic factors in influencing person’s behaviour. Also, it does not consider time frame (LaMorte, W.W., 2016).

2.9.2 Social Cognitive Theory

According to this theory, behavior is a sum of several constructs such as personal, environmental, and behavioral elements. Social learning theory

focuses on the reciprocal interaction between these factors. Each factor affects each of the others. Social Cognitive Theory (SCT), formulated by Bandura, is a three-way dynamic model in which personal factors, environmental factors, and behavior continuously interact. This theory has been widely used in the health sector. SCT is based on the concept that people learn not only through their own experiences but also by observing the actions of others and the results of those actions. The essential constructs of SCT include Observational learning, Reinforcement, Self-control, and Self-efficacy (Lent *et al*, 2019). The limitation of this theory is that it does not consider emotion or motivation in influencing the person's behaviour. The major drawback of this theory is that it assumes that person changes with the change in the environment and this may not always be true (LaMorte, W.W., 2016).

2.9.3 Trans-Theoretical Theory

The trans-theoretical theory, known as the Stages of Change model, includes five stages. These five stages are pre-contemplation, Contemplation; Preparation; Action; and maintenance. This model is widely used in the case of addictive behaviors. The basic logic of this theory is that a person at the same stage should encounter the same problems and issues and thus can be solved by the same type of intervention. The limitation of this theory is that each stage is separated and isolated, how individuals change their behavior and why some changes are more quickly than others. The other major limitation is that an individual entering the last stage of behavior can fall back into earlier stages. The factors responsible for this can be external factors like seasonal changes or other personal issues.

People do not move linearly, i.e., they can go back through the stages of change or repeat the same stage (Taylor, 2006).

2.9.4 Health Belief Model

This model presumes that beliefs about threats to an individual's well-being determine the behavior. It is a sequence of two continuous self-regulatory processes, a goal-setting phase (motivation) and a goal pursuit phase (volition). The volition stage is divided into two phases: a pre-action phase and an action phase. The motivational step includes Motivational self-efficacy, outcome expectancies and risk perceptions. The core of the Health Belief Model (HBM) is assumed to be a perceived threat linked to a person's readiness to act and thus resulting in a change. The main factors of this theory are Perceived susceptibility and perceived severity perceived benefits and perceived barriers, cues to action and self-efficacy. The vital part of this model is the perceived capacity of an individual to adapt to the behavior. The person must be competent (self-efficacy) to implement and maintain the new behavior. The limitation of this model is that the interrelations between its components are undefined. Social and economic factors are not included in it. It considers the social norms as least significant compared to the personal cognitive factors. It is incomplete to understand human

behavior as it pays insufficient attention to social factors (Walker and Jackson, 2015).

2.9.5 Diffusion of Innovation Theory

According to this model, innovation is a predictor of behavior change. Innovation can be defined as an idea, practice, or object perceived as new by individuals. This theory has been widely used in marketing, development, and health. This theory includes the four main components: innovation, communication channels, time and social systems. It is a particular type of communication where messages are concerned with new ideas. If innovations are perceived as better than the previous options regarding values, experiences, and compatibility and if they are simple (understandable), testable and show visible results, there will be a more rapid change in the behavior. The limitation of this theory is that innovations are measured through the subjective valuations of near peers rather than by experts or scientific analyses. It is also a time-consuming process (Lundblad, 2003).

2.9.6 Social Practice Theory

This theory is an umbrella approach in which human practices are a sequence of different interconnected elements such as physical and mental activities, norms, meanings, technology, and knowledge, thus forming people's behavior as a part of their everyday lives (Reckwitz, 2002). These behavior theories are not universally accepted. Some theories stress individual behavior and ignore the impact of environmental variables on behavior. Some views guide understanding the behavior, and others guide the framework for behavioral intervention; therefore, the theories' purpose is unreliable.

2.10 ANALYTICAL FRAMEWORK USED IN THE STUDY

Several studies have focused on various dimensions of public acceptance and support for wastewater reuse in a household (Dolnicar *et al.,* 2009; Adewumi *et al.,* 2010; Adewumi, 2014; Gu *et al*. 2015; Gracia-Cuerva, 2016; Peters and Goberdhan, 2016). This work focuses on the individual's behaviour (intention) and willingness as a variable to test public acceptance of recycled wastewater. One of the most influential social-psychological models for describing human behaviour is the theory of planned behaviour (TPB) (Armitage and Conner, 2001). This theory is considered the most effective tool for predicting behaviour (Ogden, 2003). Fishbein and Ajezen (1975) founded the theory of planned behaviour. According to the theory of reasoned action, the intention is a critical factor in determining behaviour. Intention acts as the best determinant of conduct and is the consequence of the sum of attitudes towards a behaviour. An individual's intention is essential in performing the behaviour (Han and Stoel, 2017). The positive or negative intentions from the personal attitudes and the social pressures (subjective norms) shape the desired behaviour (Fishbein and Ajzen, 1975).

The theory of planned behaviour is adopted to constitute a theoretical framework. According to this theory, the individual attitudes and beliefs explain the behaviour. This theory added the third set of factors affecting intention or perceived behavioural control. This is like self-efficacy, which means the perceived ease or difficulty with which the individual will be able to achieve or carry out the behaviour. Human behaviour is a direct function of intention as informed by attitudes, subjective norms and perceived behavioural control. People choose to engage in behaviours after consideration of its consequences. The primary hypothesis of this theory is that behaviour is directly determined by the intention, which in turn is explained by the attitude towards the behaviour, the subjective norms and perceived behavioural control (Ajzen, 1991, Nancarrow *et al*, 2009, Ahmmadi *et al*, 2021).

2.10.1 Attitude

Attitude is the sum of all behavioural beliefs, the expectation that showing a behaviour would result in a particular outcome. Attitude towards a behaviour is the personal feeling of favourableness and unfavourableness towards a behaviour. The attitude formation is due to the personal beliefs and is an outcome of considering consequences at the individual level (Ajezen and Fishbein, 1980). The significant factor in predicting the intention to accept wastewater reuse is attitude (Po *et al.,* 2005). In this study, an attitude refers to the participants' positive or negative character influencing their intention to accept wastewater reuse.

2.10.2 Subjective norms

Subjective norms refer to the belief about whether most people approve or disapprove of the behaviour. Subjective norms, in other words, are the social pressure, are the perceived expectations of what other people perform the alternative behaviour times the willingness to perform that expectation. It is the influence of other significant factors to perform the behaviour. It is the perception of how important people are in the life of respondents that would approve or disapprove of performing a particular behaviour (Adewumi *et al.,* 2014). The subjective norms significantly affect the intention to accept wastewater reuse (Po et, 2005; Fielding *et al.,* 2009). In this study, subjective norms refer to how social pressure affects the intention to accept wastewater reuse.

2.10.3 Perceived behavioural control

Perceived behavioural control refers to "how people perceive the level of ease or difficulty while performing the behaviour of interest". This is a function of the presence or absence of requisite resources and information to perform the behaviour (Adewumi *et al.,* 2014). Perceived behavioural control is the measurement of resources to achieve the desired outcome of the behaviour (Ajzen1991). Perceived behavioural control is a degree people have the opportunity and ability to do a particular alternate behaviour. It is the ease or

difficulty of accomplishing the behaviour. This factor has not been tested concerning the perceptions toward wastewater reuse in South Africa (Adewumi *etal.,*2014).

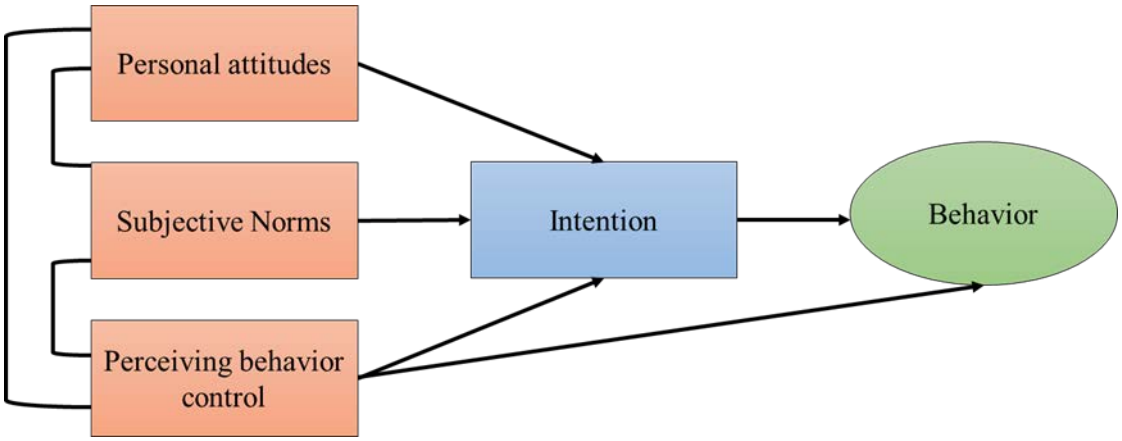


Figure 2. 3 An analytical framework based on the theory of planned behaviour for this study.

Source: Nancarrow *et al* 2009

An analytical framework used for this study is shown in Figure 2.3 and abbreviations of construct items are explained in table 2.2.

The various applications of the theory of planned behaviour have been found in different sectors. Strong correlations have been found between behaviour and attitudes and perceived behavioural control components. This model is used to explain and predict the likely behaviour but is not considered helpful in planning and designing the type of intervention for behaviour (Taylor *et al.,* 2007; Webb *et al.,* 2010). This theory has been widely applied in diverse sectors; software copying, ethical purchase behaviour, purchase of fair-trade products and avoidance behaviour towards counterfeit products (Han and Stoel, 2017). Nancarrow *et al*. (2009) also measured the predictors of communities' behavioural decisions for potable reuse of wastewater with this theory. However, this theory has also been criticised in terms of predictability. Ogden (2003) criticised that some studies using this theory showed no effect of attitude, subjective norms or perceived behavioural control on behaviour. Ajzen and Fishbein (2004) explained that the comparative importance of these three constructs could vary depending on the type of behaviour and population.
Additionally, Ajzen (1991) indicated that this theory allows adding other predictors (other than these three factors) if they increase the model's predictive power. He further suggested that this model is open to the inclusion of additional predictors. This inclusion has been widely used and applied in different sectors.
Several studies propose that public acceptance of wastewater reuse is the sum of various factors (Nancarrow *et al.,* 2009, 2010; Po *et al.,* 2005; Adewumi *et al.,* 2104). Nancarrow *et al*. (2009, 2010) and Po *et al*. (2005) found that public acceptance is a product of attitude, emotion, perceived behaviour control,

subjective norms, knowledge, risk, trust, cost, water scarcity and socio-demographic factors. Adewumi *et al*. (2104) assume that the predicted intention to accept the wastewater is influenced due to various factors like advantages of reuse, trust, attitude, perceived behaviour control, subjective norm and physical quality satisfaction. However, in the previous studies, physical quality satisfaction and subjective norm was not possible to measure because reliable scales were not assessed. Therefore, based on these studies, a hypothesised model was proposed to predict the intention to accept wastewater reuse.
Acceptance of wastewater reuse (Behaviour) is predicted from the intention of the respondents, which in turn is predicted by various variables:

Table 2. 2 Constructs measuring the intention to accept the wastewater reuse and their respective hypotheses in this study.

Item Code	Construct	Hypothesis
TRU	Trust	H1: Respondent's trust in the wastewater authorities has a positive effect on the attitude to accept the wastewater reuse.
PE	Past Experience	H2: Past Experience from the service providers has a positive impact on the Attitude.
ATT	Attitude	H3: Respondent's positive attitude towards the wastewater reuse has a significant influence on the intention to accept the wastewater reuse.
SNO	Subjective Norm	H4: Higher Subjective Norms associated with wastewater reuse positively impacts the intention to accept the wastewater reuse.
PBC	Perceived Behavioural Control	H5: Respondent's perceived control over the source of water and its application has a positive effect on the intention to accept wastewater reuse.
INT	Intention	H6: Respondent's perceived control over the source of water and its application has a positive and significant influence on the behaviour to accept the wastewater reuse.
BEHV	Behaviour	H7: Intention has a positive and significant impact on the behaviour to accept the wastewater reuse.

2.11 CONCLUSIONS

The review comprehensively analysed all factors influencing public acceptance of recycled wastewater for direct potable reuse. The main conclusions drawn from this review are: -

Mean acceptance rates for drinking applications of reclaimed wastewater are lowest compared to other applications, which are in the acceptability order of toilet flushing (87%)> landscape irrigation (86%)>cleaning (80%)>bathing (55%)>drinking (28%).

Cheaper drinking water sources can increase their willingness to purchase and consume. No change in tariff can shift public emotions to other factors such as disgust, leading to lower acceptance of reclaimed water. In addition to focusing on cost recovery, the pricing strategy for a reclaimed water scheme should be based on a system-wide approach involving all beneficiaries who benefit from the presence of reclaimed water in the water portfolio. On the tariff side, cross-subsidisation can be implemented in which the price of reclaimed water is recovered from tariffs imposed on freshwater supply to accommodate the cost of water reuse and motivation for the public to accept low-priced reclaimed water.

Religion is an influencing factor in accepting reclaimed wastewater for direct contact applications. Proper guidance from religious scriptures can avoid this factor. Questions and concerns from sensitive religious communities should be addressed at the planning stage of the reclamation project rather than after implementation—this contextualisation of marketing message to the communities rather than one message for all. The literature about public acceptance of reclaimed wastewater in major global religious sectors such as Christians, Hindus, and Buddhists is not available, which indicates that future research directions should be to evaluate and comparatively assess the perceptions of these communities.

The role of media is essential to disseminate the information and the timely knowledge about the importance of wastewater rec in efficient water management and its potential to provide reliable, safe water during the drought.

Branding the reclaimed wastewater is one strategy that depends upon identifying desirable and undesirable water attributes in public perception. A research requirement is to identify which attributes users want to be visible in the reclaimed wastewater, which will help formulate the direction of marketing campaigns for the reclaimed water.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methods enable a researcher to adopt the strategies to achieve the objectives proposed in the study. This chapter discusses the methodology adopted to collect data from public and religious groups, evaluate the reliability of the data and analyze the obtained data using appropriate statistical methods to achieve study objectives. More specifically, the chapter discusses hypotheses, sampling methods, research design, the validity of data and the method of structural equation modelling used to validate the hypothesis.

3.2 RESEARCH DESIGN

Three types of research design are descriptive, exploratory and conclusive research. For this study, descriptive and conclusive research designs have been used. Descriptive research is adapted when the main aim is to define the underlying factors of the study, and conclusive is used when the aim is to describe specific phenomena, testing hypotheses and examining the relationships. The data obtained from this design is subjected to analysis (Malhotra and Birks, 2006).

3.3 RATIONALE FOR THE METHODOLOGY

The quantitative and deductive approach was used as research methodology. The limitations of adapting quantitative research approach is that it lacks precision because people may misinterpret the questions posed in the questionnaire and that may affect the objectives of the study. This approach is not linked to real life because responses can differ from the actual behaviour. Although the merits of quantitative research approach are validity, reliability, and generalization and which are important for quality criteria of the study (Bryman, 2012).

For this study, the research method used was quantitative, as the data was collected from the respondents with the help of a well-structured questionnaire. The deductive approach is used when there are already known theories related to the study and hypotheses are formulated from them (Bryman and Bell, 2011). For this study, the theories of public perception and the factors influencing the constructs were thoroughly studied and thereafter, hypothesis have been developed. The hypotheses are of two types: the null hypothesis and an alternate hypothesis. The objectives of this study were used to generate the hypotheses.

3.4 THE RESEARCH PHILOSOPHY

The research paradigm includes philosophical rules and beliefs that helps in executing the research. The research philosophy helps to define the world, emphasizing an individual's role in it and the relationship in that world (Jonker and Pennik, 2010). The two types of paradigms are: Epistemology and ontology. Epistemology deals with the researcher's views and is concerned with the reality and the basics of knowledge (Bryman and Bell, 2011). It is further categorized into two groups namely positivism and interpretivism. Ontology on the other hand is defined as researcher's perceptions, whether reality is external to social actors or is created by social actors. It is further divided into two types: objectivism and constructivism (Saunders *et al*, 2009).

For this study, positivism paradigm is used. It refers that the social phenomena are studied with natural science rules, where they collect, analyze and process data (Saunders *et al*, 2009). According to Bryman and Bell (2011), knowledge is obtained through testing the hypotheses (objective methods). The theories of public perception and factors affecting it were studied. The objectives were generated from thorough review of literature and hypotheses were refined. A survey was conducted from the respondents and the data generated was thoroughly analyzed. This was all accomplished without the interaction of the researcher with the research environment.

3.5 RESEARCH STRATEGY

There are various strategies used in the research. These include experiments, surveys, ethnography, case study, focus groups, and interviews.

For this study, case study "eThekwini Municipality" have been used as a research approach. A case study is a research strategy that involves in-depth investigation of a particular phenomenon, person, group, or event within its real-life context. Case studies are commonly used in social sciences, business, education, and other fields to understand complex phenomena, generate new ideas, or test theoretical propositions. Case studies typically involve multiple sources of data, including interviews, observations, documents, and artifacts (Bryman and Bell, 2011). One of the main advantages of case studies as a research strategy is their ability to provide rich, detailed information about a particular phenomenon. This information can be used to generate new hypotheses, theories, or models, or to challenge existing ones. Case studies can also be used to explore the complexity and dynamics of real-life situations, and to generate insights that cannot be obtained through other research methods. However, case studies also have some limitations. Because they focus on a specific case or group of cases, the findings may not be generalizable to other contexts or populations. Additionally, case studies may be influenced by the researcher's subjective interpretation of

the data, and the results may be difficult to replicate or validate. Overall, case studies are a useful research strategy for exploring complex phenomena in depth and generating new insights and ideas (Silverman, 2011).

For this study, surveys (questionnaires) have been used as research method and it includes various forms, questionnaires, mail surveys, door to door surveys and telephonic surveys. The questionnaire is the most widely used research instrument in almost all survey methods because of its advantages (i.e., the ease of administering, easy analysis, and less costly). There are various limitations of using questionnaires, sometimes the respondents ignore and left questions unanswered, also the questionnaire cannot fully capture emotions and feelings, some questions are difficult to analyze, and respondents bias can be an issue (Bajpai, 2011).

3.6 SAMPLING STRATEGY

The two types of sampling are probability and non-probability sampling. In probability sampling, the probability, or the chance of being selecting for the sample is known and equal whereas, it is unknown for non-probability sampling (Kothari and Garg, 2015). The different forms of probability sampling are simple random sampling, stratified random sampling and systematic random sampling. Whereas, convenience, purposive, quota and snowball sampling are the types of non-probability sampling. For this study, proportionate stratified sampling was used (Bajpai, 2011).

3.7 LOCATION OF STUDY

The eThekwini municipality is the largest in the province of KwaZulu Natal (KZN) in South Africa and ranks the third largest municipality in the country (MOSA, 2022). It is situated on the east coast of South Africa and divided into 103 wards;

most wards are near Durban.

Figure 3. 1 Map of eThekwini Municipality and location of Durban city (MOSA, 2022)

3.8 TARGET POPULATION

The target population for the study was the population in the suburbs of Durban, a coastal city in eThekwini Municipality (Stats SA, 2019). Population data used to calculate sample size and racial distribution is captured from Statistics South Africa (Stats SA, 2019). Statistics South Africa is a national statistical service of South Africa which produce official statistics for economic growth, development, and democracy. The total population of Durban city was 595061, out of which the target population was selected based on the racial groups.

3.9 SAMPLE SIZE

The different racial and ethnic groups were selected to involve participants in the survey in eThekwini Municipality. A sample of 384 residents was selected from the Durban city. The total number of samples to estimate the representative

number for the study is calculated from the following equation (Massoud *et al.,* 2018):

$$\boldsymbol{n} = \frac{\boldsymbol{Z}_{0.95}^{2} \times \boldsymbol{p}(\boldsymbol{1}-\boldsymbol{p}) \times \boldsymbol{N}}{(\boldsymbol{N}-\boldsymbol{1}) \times \boldsymbol{m}^{2} + \boldsymbol{Z}_{0.95}^{2} \times \boldsymbol{p}(\boldsymbol{1}-\boldsymbol{p})} \qquad \text{Equation 1}$$

Where n= required sample size,

Z = Confidence level set to 95% (Standard value of 1.96)

P = estimated prevalence of the outcome variable, 0.5 to get a maximum sample size

N = total number of the population

m = margin of error set to 5% (standard value of 0.05)

According to Sekaran and Bougie (2016), as the population increases, the sample size increases at a diminishing rate and remains relatively constant at slightly more than 380 cases. Based on this criterion, the total sample size for all racial groups in the Durban city was 384 out of the total population of 595061 (Stats SA, 2019).

If the population from which the sample is drawn does not form a homogeneous group, then the stratified sampling technique is applied to get a representative sample (Kothari and Garg, 2015). For this study, the population of Durban was divided into the various racial groups (homogeneous groups or strata) and sample items were chosen from each stratum. So, the sample selection was ruled by proportionate stratified sampling, whereby the respondent was taken from each group. After classifying, care was taken that the number of respondents from each stratum is proportionate to the stratum's size concerning the total population. This was obtained by calculating the stratified number of samples from each racial group as (sample size/population size) x size of the stratum. The sample size was calculated from equation 1 (384), the population size was the population of the Durban, and the stratum size was the population of a particular race in Durban. Table 3.1 shows the population distribution and the sample size chosen from each group. Estimates of population based on the probability sampling usually have greater precision (or smaller sampling error) than if the whole population were sampled by non-probability sampling (Kothari and Garg, 2015).

Table 3. 1 Distribution of participants in Durban based on the racial groups and stratified sampling method.

Race	Percentage of population	Population of Durban	Population	Sample Size Durban	Proportional Sample Size
Black African	51.1	595061	304076	384	196

Indian /Asian	24	595061	142815	384	92
White	15.3	595061	91044	384	59
Coloured	8.6	595061	51175	384	33
Others	0.9	595061	5356	384	4

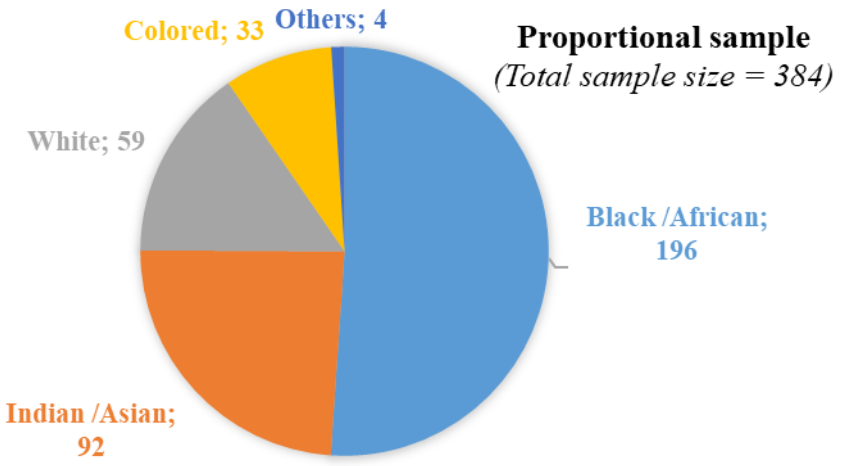


Figure 3. 2 Proportional sample from Durban, selected for this study.

Source: Author's Compilation

3.10 RELIGIOUS GROUPS

A separate questionnaire was provided to local religious councils to study the religious views towards wastewater reuse and their interest in motivating the public to accept recycled water. Religious distribution in KZN includes the main religions as 79% Christianity, 2% Muslims and 4% Hindu (StatsSA, 2019). Representatives of three groups/organisations in each religion surveyed are as follows:

- Islam (Jamiat Ul Ulama, KZN, Islamic Dawah Movement, Darul Ihsan)
- Christianity (African Methodist Episcopal Church, Anglican Church of Southern Africa, Apostolic Faith Mission of South Africa)
- Hinduism (South African Hindu Maha Sabha, Natal Tamil Vedic Society, South African Tamil Federation)

3.11 DATA COLLECTION METHODS

This study used both primary and secondary data, whereby the research approach was quantitative. Two separate questionnaires were used to gather data from the public and religious experts. Since it was impossible to reach out to distant suburbs and population groups due to limited contacts and Covid-19 restrictions including lockdowns, hand-to-hand and online surveys (through emails) were used to collect data. In primary data collection, data was gathered through the survey method. Secondary data was gathered from books, newspapers, magazines, online sources, project reports, and national and international journals like Emerald group publishing, Taylor and Francis, Springer and JSTOR (American Marketing Association).

3.12 PILOT STUDY

To identify the possible problems in the instrument regarding the clarity of variables, response format and understanding of the questions, pilot testing was conducted before the survey. Random sampling was chosen to select 60 respondents who were separate from the main participants. The respondents reported no major problem. Exploratory factor analysis was conducted to define and explore the factors and to know the dimensionality. It resulted in the deletion of some inappropriate items from the behavioural intention and two items from "Trust" due to low factor loading below 0.5. Reliability and validity analyses were conducted on the data set, Cronbach alpha was found to be greater than 0.75, and therefore, the scale was accepted. The final instrument after testing, was used for the survey.

3.13 RESEARCH INSTRUMENT

A questionnaire was used to gather the data. The first part of the questionnaire deals with an individual's demographic characteristics like age, gender, educational qualification, and income. Apart from the demographic characteristics, the need was felt to quantify the data. Therefore, Rensis Lickert's popularly known as Lickert's type technique was applied throughout this study. The respondents were asked to respond to each item on a particular issue under study in terms of several degrees of agreement, disagreement, viz., strongly agree; agree; neutral; disagree; and strongly disagree (strongly disagree = 1, strongly agree = 5). There were some questions related to knowledge and marketing strategies to get insights into the problems faced by the respondents.

The questionnaire was distributed in person and through emails within the city of Durban. A total of 352 responses were acknowledged from the total sample size of 384, constituting a 91.6% response rate for the study. Out of 352 respondents, 298 have completed all the questions that were required to be answered. The

responses from 54 respondents were incomplete and missing. The 298 responses gathered from the public were being analysed through SPSS 20 software, and AMOS 23 was used for Structural Equation Modelling and the development of the measurement model. The items of each construct are discussed in Table 3.2.

3.14 ADMINISTRATION OF QUESTIONNAIRE

After the pilot testing, an online Google Forms questionnaire was prepared to gather the primary data. The questionnaire was shared online with the target population. The author attended meetings of the community representatives at the Remix demonstration wastewater reuse plant at Bluff, Durban. These meetings were arranged by the Department of Water and Sanitation of eThekwini Municipality for public engagement in wastewater reuse. The author introduced the study objectives and requested participation in the study. The employees of various organisations and universities in Durban were invited through emails. The university students were requested to participate in informing them in their online student groups.

3.15 CRITERIA FOR GOOD MEASUREMENT

There are three basic criteria for a good measuring instrument or questionnaire. These are validity, reliability and sensitivity.

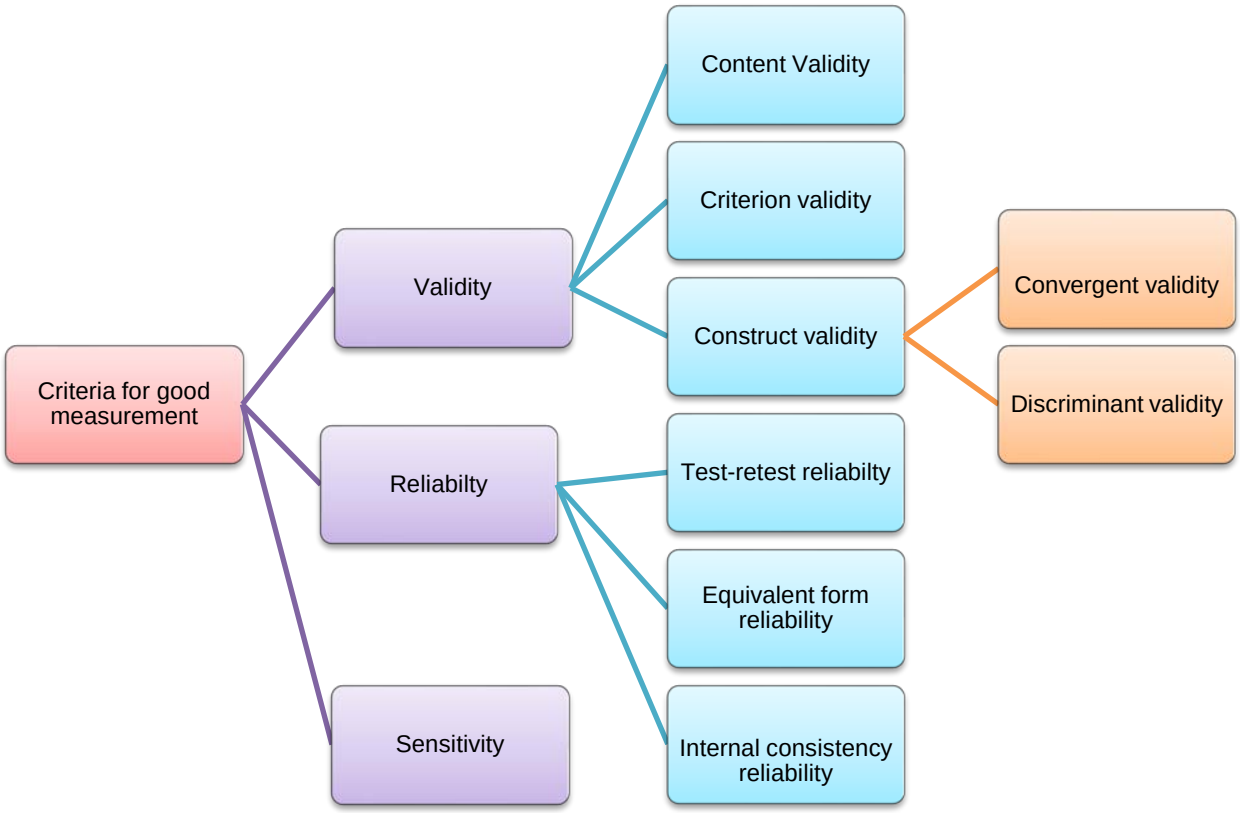


Figure 3. 3 The criteria for good measurement

Source: Adapted from Bajpai (2011)

3.15.1 Validity

Validity is defined as an instrument's capability to measure what it is intended to measure (Morgado *et al.,* 2017). The validity assessment can be done with three basic approaches: content validity, criterion validity and construct validity.

Content validity

It is also known as face validity, in which the experts examine the content of the measuring instrument. It is the subjective assessment of the scale for its ability to measure what it is designed to measure. For this study, several meetings were conducted with the experts (Supervisors and researchers) in this area, and some content and wording were further improved. Also, public participation meeting with the REMIX treatment plant gave us knowledge about some critical issues, which were incorporated into the questionnaire.

Criterion validity

A variable can identify the key variables or criteria. It includes various factors or constructs designed to measure what it is designed to measure. It may include demographic and psychographic characteristics, attitudinal and behavioural measures, or scales obtained from other scales (Kanya *et al.,* 2019). For this study, various demographic characteristics, behavioural, trust, risk, experience and subjective norm measures were obtained from other scales.

Construct validity

The initial concept determines which data will be generated and how they will be gathered (Golafshani, 2003). The theory and the measuring instrument are considered (Bajpai, 2011). It is further divided into two types: convergent validity and discriminant validity. It is called convergent validity when the new measure converges or correlates with other similar measures. For this study, the factor loadings of all constructs were above the recommended threshold value of 0.5.

3.15.2 Reliability

Reliability is the ability of a respondent to respond in the same manner to an identical or near-identical question. A measure is reliable when it produces the same response from the same person when given to a person in similar or similar circumstances. Various measures such as Cronbach's alpha and composite reliability are used to measure internal consistency reliability. It measures the reliability of a summated scale by which several items are summed to form a total score (Kanya *et al.,* 2019). The co-efficient or Cronbach's alpha estimates the correlation coefficient of measurement items in a test. A co-efficient value varies

from 0-1; a value of 0.6 or less is considered unsatisfactory. A 0.7 or above indicates high internal consistency or reliability (Bajpai, 2011).

3.15.3 Sensitivity

It refers to the ability of a measuring instrument to measure the meaningful difference in the responses. "Yes," or "No" responses known as dichotomous categories can generate a high variability in the responses. A scale having five categories of responses such as "strongly agree", "agree", "neither agree nor disagree", "disagree", and "strongly disagree" is considered a more sensitive measuring instrument. Single question scales must be avoided to increase the instrument's sensitivity (Bajpai, 2011). For this study, the Likert scale was used to measure the perception of acceptability of wastewater reuse.

3.16 VARIABLES AND MEASURES

For this study, the pool of items was generated for the selection of the sample of items. A total number of 29 items has been finally identified from literature to get various constructs with four items for "Trust", four items for "Past Experience", six items for "Attitude", two for "Subjective Norm", three for "Perceived Behavioural Control", seven items for "Intention" and three items for "Behaviour". All these items were screened out for ambiguity, clarity, and adequacy.

Table 3. 2 Items selected for various constructs.

Item Code	Variable	Reference
TRU	**Trust**	
TRU_1	I have confidence that the local municipality will deliver satisfactory services	Wilson, 2008
TRU_2	I think that the local municipality has good intentions in managing Durban's water supply.	Goodwin, 2018
TRU_3	I can depend on the water authority to provide a good quality water supply.	Wilson, 2008
TRU_4	I have complete trust in the water authority to provide me with good quality water supply.	Wilson, 2008; Ross *et al*, 2014
PE	**Past Experience**	
PE_1	The local municipality is competent enough to manage our water supply.	Ross *et al*, 2014
PE_2	The local municipality provides the Durban community with the necessary information they want to know about their water supply.	Ross *et al*, 2014
PE_3	The local municipality does not listen to concerns raised by people like me	Ross *et al*, 2014

PE_4	The local municipality acts in the public interest when it comes to water quality	Ross *et al*, 2014
ATT	**Attitude**	
ATT_1	There would be possible problems or risks associated with the recycling scheme.	Ross *et al*, 2014
ATT_2	Drinking recycled water will pose a health risk to me.	Nancarrow *et al*, 2009
ATT_3	There is a lack of qualification, experience and skilled operators in our municipality which can result in poor operation of the recycle technology causing a health risk.	West *et al*, 2016
ATT_4	Due to corruption in our country, a cheaper technology will be adopted in the recycle water project that will not be efficient to deliver safe drinking water.	West *et al*, 2016
ATT_5	Customer complaints by local municipality are not addressed well. I feel, poor water quality concerns, aesthetic concerns and/or price concerns about recycled water will not be addressed.	West *et al*, 2016
ATT_6	Local municipality lacks real time interactions with public and critical updates are delivered lately. So, there is always a perception of health risk, in case there is any accident at recycled water treatment works.	West *et al*, 2016
SNO	**Subjective Norm**	
SNO_1	My religion does allow for the use of recycled water.	Nancarrow *et al*, 2009
SNO_2	I believe that this recycling scheme will be safe to use.	Nancarrow *et al*, 2009
PBC	**Perceived Behavioural Control**	
PBC_1	I would protest against purified recycled water being added to my drinking water.	Nancarrow *et al*, 2009
PBC_2	Given the choice, I would not drink water that contained purified recycled water.	Nancarrow *et al*, 2009
PBC_3	I would complain to the government if purified recycled water was added to our drinking water in the dam/ reservoirs.	Nancarrow *et al*, 2009
INT	**Intention**	
INT_1	I would be willing to use recycled water for watering gardens	Goodwin, 2018
INT_2	I would be willing to use recycled water for flushing toilets.	Goodwin, 2018
INT_3	I would be willing to use recycled water for washing dishes	Goodwin, 2018
INT_4	I would be willing to use recycled water for washing clothes	Goodwin, 2018
INT_5	I would be willing to swim in water containing some recycled water.	Goodwin, 2018

INT_6	I would be willing to buy a home that uses recycled water for watering gardens and flushing toilets.	Goodwin, 2018
INT_7	I would be willing to consume food irrigated with recycled water.	Goodwin, 2018
BEHV	**Behaviour**	
BEHV_1	I support adding purified recycled water to our water supply in the dam.	Nancarrow *et al*, 2009
BEHV_2	I do not want purified recycled water to be mixed with my drinking water.	Nancarrow *et al*, 2009
BEHV_3	I would drink the water that was provided by this recycling scheme.	Nancarrow *et al*, 2009
	Future marketing Strategies	Garcia-Cuerva *et al*, 2016
	Knowledge	
	What is the main source of drinking water which is coming in your taps?	Q. Gu *et al*, 2015
	Which sector is the biggest user of water in Durban?	Q. Gu *et al*, 2015
	Does Durban have sufficient water?	Q. Gu *et al*, 2015

3.17 NORMALITY

The normality assumption specifies that the sample data is drawn from a normally distributed population. The properties of a normal distribution are that the mean, median, and mode are equal, and the curve is horizontal and never touches the x-axis. The sample drawn from such a population is expected to be distributed normally. It is important to check the normality assumption to decide whether parametric or non-parametric tests will be used. The different approaches for checking the normality are Skewness and Kurtosis values, Kolmogorov- Smirnov (KS) test and Shapiro-Wilk (SW) test or by looking at the histogram of dependent variables. However, the skewness and kurtosis values are commonly used to check the sample mean normality. The reasons are broader flexibility in the reference values of skewness and kurtosis, and, it is easier for the researcher to show normality by using skewness and kurtosis values (Orcan, 2020). The values for the Skewness and Kurtosis for normal distribution lie between -3 and +3, and -8 to +8, respectively, are considered acceptable (Kyriazos, 2018).

3.18 DESCRIPTIVE STATISTICS

Descriptive Statistics include the number of techniques that allow the researcher to tabulate and summarize the research parameters for a given study. The objective was to analyze the structure of the sample. The different statistics include frequencies, mean, mode and standard deviation. Before carrying out these tests, the normality test was done to decide whether to apply parametric or

non-parametric statistics. The normality of data was ascertained by computing the skewness and kurtosis statistics (Bajpai, 2011).

3.19 STATISTICAL TECHNIQUES USED

Over the years, various techniques have been used to help researchers. Statistical techniques for analysis can be done by two approaches: univariate and multivariate. Univariate statistical techniques are used when only one measurement of each element is taken. Multivariate statistical techniques analyze two or more measurements (Morgado *et al.,* 2017). It can be further divided into parametric (metric) data and non-parametric (non-metric) data. Non-parametric tests are conducted when the data are nominal or ordinal, whereas parametric tests are used when the data are interval or ratio. It depends on the population's restrictive normality assumption (Bajpai, 2009). The other primary techniques are Factor Analysis, Discriminant Analysis, Multi-attribute Compositional Models and Multidimensional Scaling.

3.20 MODEL MEASUREMENT

3.20.1 Structural Equation Modelling

Structural Equation Modelling (SEM) is a statistical approach to testing hypotheses about relations among observed and latent variables. The five steps involved in SEM are Model Specification, Identification, Parameter Estimation, Model Evaluation and Model Modification (Kyriazos, 2018). Therefore, it is a method of representing, estimating, and testing a network of relationships between variables. It estimates and tests a series of hypothesized interrelated relationships between a set of latent constructs. The term 'Structural' assumes that the construct shows a causal relationship. The two goals are to know the patterns of correlation or covariance among the variables and to describe the variance as much as possible. It involves two primary analyses to get the model; one is Path analysis (regression), and another is confirmatory factor analysis (CFA) (Kyriazos, 2018). In SEM, latent variable models can be specified and provide estimates of relations among their latent construct and manifest indicators. The advantages of SEM are the calculation of measurement error, estimation of latent variables via observed variables and model testing. The availability of measures of global fit provides a summary evaluation of even complex models. Thus, SEM supports the model comparison approach to data analysis in this regard. A sample size of 200-400 is appropriate for SEM (Kyriazos, 2018).

3.20.2 Factor Analysis

Factor analysis is a multivariate statistical approach commonly used in psychology, education, and, more recently, in the health-related professions.

Factor analysis reduces many variables into a smaller set of variables (also referred to as factors). Secondly, it establishes underlying dimensions between measured variables and latent constructs, thereby allowing theory formation and refinement and providing construct validity evidence of self-reporting scales (Williams, B., *et al*. 2010). Factor analysis operates on the notion that measurable and observable variables can be reduced to fewer latent variables that share a common variance and are unobservable, known as reducing dimensionality (Bartholomew, Knott, & Moustaki, 2011). The general purpose of factor analysis is to summarise data so that relationships and patterns can be easily interpreted and understood. It is commonly used to regroup variables into a limited set of clusters based on shared variance (Yong and Pearce, 2013). The two main factor analysis techniques are Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). CFA attempts to confirm hypotheses and uses path analysis diagrams to represent variables and factors, whereas EFA tries to uncover complex patterns by exploring the dataset and testing predictions (Child, 2006).

3.20.3 Correlation Matrix

A correlation matrix summarizes the interrelationships among a set of variables, in our case, a set of items in a scale. The most common form of correlation matrix used in factor analysis is a matrix consisting of Pearson product-moment correlations (also called Pearson r or rxy). It is a simple correlation matrix of all the pairs of variables included in the factor analysis. In the correlation matrix, the diagonal element always equals one, indicating any variable's correlation with the same variable (Bajpai, 2011).

3.20.4 Bartlett's Test of Sphericity

This statistic tests the null hypothesis that the correlation matrix is an identity matrix (i.e., no relationship exists among the items). The null hypothesis states that there is all 1's on the diagonal of the matrix and 0's on the off diagonal. A value less than 0.05 indicates that the data in hand do not produce an identity matrix. This means a significant relationship exists among the variables taken for the factor analysis (Bajpai, 2011).

3.20.5 Kaiser-Meyer-Olkin Test (KMO)

The Kaiser-Meyer-Olkin test (KMO) is a measure of sampling adequacy that compares the magnitudes of the calculated correlation coefficients to the partial correlation coefficients. In other words, this is the common variance attributed to the underlying factors. A high value of this statistic (from 0.5 to 1) indicates the appropriateness of the factor analysis for the data at hand. In contrast, a low statistic value (below 0.5) indicates the inappropriateness of the factor analysis (Bajpai, 2011).

3.21 DELIMITATIONS

The data for this study was from the citizens of the suburbs of Durban city in South Africa. The recycling plants are in the demonstration phase with the local eThekwini Municipality, assuming the local municipality is in the planning stage of implementation of wastewater recycling in the study area.

The religious aspects of wastewater recycling were limited to religious organizations working in these suburbs of the Durban. The selected religious organizations were functional and contributed significantly to the religious aspects of the respective communities.

3.22 LIMITATIONS

The research was carried out in the eThekwini municipality, and the religious organizations were selected based in the Durban. Only suburbs of Durban were selected for the study due to financial, time and COVID-19 constraints. Furthermore, the study was focused on the perception of wastewater recycling irrespective of the certainty of the provider whether the participants will be supplied with recycled water in future or not.

3.23 ETHICAL CONSIDERATIONS

The research involving human beings' data collection is evaluated based on ethical issues (Sekaran and Bougie, 2016). The data must be collected while maintaining the confidentiality and privacy of the participants to ensure no compromise with their self-respect and self-esteem. The violation of ethical issues includes interfering with non-disclosure agreements, disclosure of participants' identities and responses to other participants and breaking the legal terms and conditions (Blumberg *et al.,* 2014).

In this study, the study's details, objectives and approach were detailed to the participants at the introductory session and at the time of taking responses. The information letter containing the study details duly approved by the Durban University of Technology was shared with the participants. The risks associated with the participation in the study and the terms of maintaining anonymity were also detailed to the participants before taking responses. The online questionnaire was developed with a feature that the participants cannot see the responses other participants gave. These ethical guidelines were according to rules and procedures established by the ethical department of the Durban University of Technology.

3.20.1 Confidentiality

Confidentiality in social research refers to not revealing the participant's identity to each other or someone else, and this should be adhered to while conducting data collection (Clow and James, 2013). In this study, the rules of confidentiality framed out by the Durban University of Technology were followed, and the same was revealed to the participants at the time of introduction. The data obtained was not shared with anyone who was not associated.

3.20.2 Anonymity

The names of participants were not revealed in any table or figure which explains the results obtained from the survey. The anonymity of the participants must be maintained in the social science research, and the same should be revealed in the invitation letter to the participants (Clow and James, 2013). The anonymity of the participants was ensured by strictly following ethical guidelines by the Durban University of Technology.

3.21 CONCLUDING SUMMARY

This chapter focuses on data collection methods and various research methodology aspects such as research design, sample size and design, and research instrument. Also, pilot study and normality is briefly mentioned. It also discusses the different types of variables and constructs related to the study. Different types of tests and analytical models used for the study are briefly discussed in this chapter. The Statistical Package for Social Sciences (SPSS) v 22.0 and Analysis of Moments of Structure (AMOS) v 24.0 are the statistical software tools used for data analysis.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter discusses the results obtained by administering questionnaires to the participants, the testing of the reliability of the data and the validation of the hypotheses proposed in the study. The results obtained after using statistical techniques, as discussed in chapter 3, are explained in this chapter. The focus of the study was to study the public perception of wastewater recycling in households. The second part of the chapter discusses the results obtained from administering the open-end questionnaire to religious groups.

4.2 DEMOGRAPHIC DIFFERENCES

To evaluate and measure whether there exists any difference in the perception of the acceptability of wastewater reuse, a one-way ANOVA was used for each demographic factor, gender, age, education, religion, and income.

To achieve the objective "to evaluate socio-demographic variables including gender, age, education, religion, and income level on the willingness towards the wastewater reuse, one-way ANOVA was used for the acceptance items and these demographic factors.

4.3 ONE-WAY ANOVA ACROSS GENDER AND ACCEPTANCE

One-way ANOVA was conducted to check the significant difference in the perception of acceptance across the gender of the respondents. As shown in Table 4.1, the outcomes revealed that gender has an insignificant effect on the acceptance of wastewater reuse. (P>0.05). These are consistent with the findings of several studies that found no significant difference between genders and the acceptability (Hurlimann, 2006; Robinson *et al.,* 2005; Gu *et al.,* 2015).

Table 4. 1 One-way ANOVA between Gender and Acceptance

S.No.	Variable	Gender	Mean	Standard Dev.	F value	Sig.
1	BEHV_1	Prefer not to say	3.33	.866	1.232	.161
		Male	2.72	.718		

		Female	2.60	.912		
		Total	2.68	.968		
2	BEHV_3	Prefer not to say	3.44	.830	1.636	.197
		Male	2.88	.673		
		Female	3.00	.844		
		Total	2.95	.512		

4.4 ONE-WAY ANOVA ACROSS AGE AND ACCEPTANCE

One-way ANOVA was used to test the significant difference in the perception of acceptance across the age of the respondents. The outcomes depicted in the Table 4.2 revealed that age has an insignificant impact on the acceptance of wastewater reuse. (P>0.05). Also, various studies stated that no significant relationship exists between age and acceptability of wastewater reuse (Velasquez and Yanfu, 2015; Gu *et al.,* 2015; Hurlimann *et al*, 2008).

Table 4. 2 One-way ANOVA between Age and Acceptance

S.No.	Variable	Age	Mean	Standard Dev.	F value	Sig.
1	BEHV_1	<25	2.45	.783	1.297	.271
		25–35	2.59	.677		
		36–45	2.76	.999		
		46–55	2.74	.867		
		>55	3.13	.726		
		Total	2.68	.868		
2	BEHV_2	<25	2.97	.617	1.019	.398
		25–35	2.83	.927		
		36–45	3.07	.728		
		46–55	2.85	.989		
		>55	3.25	.455		
		Total	2.95	.762		

4.5 ONE-WAY ANOVA ACROSS EDUCATION AND ACCEPTANCE

The results, as demonstrated in Table 4.3, showed that education significantly influences the acceptance of wastewater reuse since P < 0.05. The outcomes are consistent with previous studies' results; the education level shows a significant relationship with the acceptability of wastewater reuse (Baghapour *et al.,* 2017). The participants with a high school education were more willing to accept the wastewater used for potable and non-potable uses (Peters and Goberdhan, 2016).

Table 4. 3 One-way ANOVA between Education and Acceptance

S.No.	Variable	Education	Mean	Standard Dev.	F value	Sig.
1	BEHV_1	Never been to school	3.00	.865	4.121	.003
		Primary school	3.24	.723		
		High school	2.93	.974		
		Bachelor's degree	2.61	.710		
		Post Graduate degree	2.51	.885		
		Total	2.68	.968		
2	BEHV_2	Never been to school	2.83	.869	3.764	.005
		Primary school	3.44	.917		
		High school	3.18	.995		
		Bachelor's degree	2.98	.992		
		Post Graduate degree	2.70	.705		
		Total	2.95	.812		

4.6 ONE-WAY ANOVA ACROSS RELIGION AND ACCEPTANCE

As shown in Table 4.4, the results revealed that religion has an insignificant impact on the acceptance of wastewater reuse (P>0.05). Masoud *et al*. (2018) found a positive relationship between religious beliefs and respondents' willingness to accept wastewater reuse. The people who showed unacceptance of wastewater reuse based on religious beliefs were twice less than those who accepted the wastewater on a religious basis. According to the study by Wilson and Pfaff (2007), there are no religious conflicts regarding accepting recycled wastewater locally and internationally. The organisation of the Eminent Scholars of Saudi Arabia, an eminent Muslim organisation, has also approved reusing wastewater for religious applications (Faruqui *et al.,* 2001).

Table 4. 4 One-way ANOVA between Religion and Acceptance

S.No.	Variable	Religion	Mean	Standard Dev.	F value	Sig.
1	BEHV_1	Others	3.50	.926	2.014	.093
		Christianity	2.59	.873		
		Islam	2.63	.899		
		Hinduism	2.75	.981		
		Traditional African Religion	2.79	.985		
		Total	2.68	.968		
2	BEHV_2	Others	3.13	.946	.950	0.435
		Christianity	2.84	.825		
		Islam	2.93	.815		
		Hinduism	3.05	.937		
		Traditional African Religion	3.11	.933		
		Total	2.95	.812		

4.7 ONE-WAY ANOVA BETWEEN INCOME LEVELS AND ACCEPTANCE

As presented in Table 4.5, the results showed a significant impact of income levels on acceptability ($P < 0.05$). Also, a study conducted by Hurlimann (2008) has revealed that income affects the acceptability of wastewater reuse. A significant link was found between income and the acceptance of wastewater reuse. Interestingly, the low-income and high-income groups were twice as willing as the middle-income groups (Peters and Goberdhan, 2016).

Table 4. 5 One-way ANOVA between Income level and Acceptance

S.No.	Variable	Income level	Mean	Standard Dev.	F value	Sig.
1	BEHV_1	<R5000	2.90	.905	1.850	0.038
		R5000–R10000	2.63	.858		
		R10000–R15000	2.76	.971		
		>R15000	2.52	.951		
		Total	2.68	.968		
2	BEHV_2	<R5000	3.28	.837	2.428	0.046
		R5000–R10000	2.82	.966		
		R10000–R15000	3.01	.973		
		>R15000	2.80	.955		

		Total	2.95	.912		

4.8 KNOWLEDGE ABOUT WATER SECTOR AND RECYCLED WASTEWATER

Public opposition to wastewater reuse can be due to risks, fear, attitude, distrust, lack of knowledge and religious prohibitions (Friedler *et al.,* 2006; Wester *et al.,* 2015). Therefore, this analysis section has attempted to understand some of the primary issues concerning the acceptance of wastewater reuse.

The questions were asked to the participants to assess knowledge about water and recycled wastewater and the responses received are summarised in Table 4.6. Knowledge is among the main factors contributing to the acceptance of recycled wastewater. The response rates showed that most of the questions related to testing the water-related knowledge of participants were wrongly answered by most participants indicating the need to educate citizens of Durban about water-related aspects. The question related to the definition of recycled wastewater was correctly answered by 23.8%, while 64% of the respondents consider conventional drinking water treatment and rainwater harvesting as recycled water. This is consistent with the previous study of Massoud *et al*. (2018). Almost half of the participants were aware of the term wastewater reuse, 34% had not heard it before, and nearly 20% had heard it but did not know why it was used. Also, according to Alhumoud and Madzikanda (2010), almost 38% of the participants had not heard of the term wastewater reuse. Approximately 47% had some knowledge but did not know why it was used, and 14% knew about wastewater reuse. This suggests that the concerned department responsible for wastewater recycling in Durban should consider creating public awareness to implement any recycled wastewater scheme successfully.

Knowledge about water scarcity is an essential driver in increasing public acceptance of recycled wastewater. Less than half of the respondents (46.3%) were knowledgeable about water scarcity in Durban, 24.5% responded that there is sufficient water, and 29.2% responded with having no idea about the water scarcity in Durban. Unless there is a realisation of water scarcity in a region, the citizens may find it challenging to adopt alternate water supply from recycled wastewater. According to the study by Bakopoulou and Kungolos (2009), most people are unaware of the water shortages and consider the reuse of water useless. Almost 50% of the respondents assumed that there is plenty of fresh water to use and thus wastewater reuse is not needed. Perters and Goberdhan (2016) asked participants about the water shortages on the

scale of never, rarely, frequently and sometimes experienced. 8% of participants stated they never experienced water shortages, 41% rarely, 16% frequently, and 35% sometimes experienced water shortages. Similarly, less than half of the respondents correctly answered the question related to the biggest water user in Durban (45.3%). This was followed by 22% of respondents who consider industries as the primary water user in Durban.

The question pertained to the water source in a drinking water treatment plant (DWTP) as Dams 55% of respondents. In comparison, 12% consider groundwater as a source of raw water in a DWTP, and 20% of respondents expressed having no idea about it. The criteria set for the knowledge in this study was 75% as a correct response. This criterion of 75% was decided based on the literacy rate in SA, which is 91% as of 2019 (StatsSA, 2019). This percentage is based on the passing of grade 7. However, if introduced at the school level, the water treatment-related knowledge can be evaluated after passing matric exams. The matric pass percentage of KwaZulu Natal ranged from 75-80% from 2018-2019 (StatsSA, 2019). However, that correct response rate was not achieved in any of the questions. The education level of the participants in this study showed that 90% had education above high school, in which 41.6% were bachelors, 33.2% were postgraduates, and 14.4% were high school pass-outs. This sample of educated respondents and not achieving the 75% criteria of correct answers to knowledge questions may indicate an urgent requirement for informing the public in Durban about various aspects of the water industry.

Table 4. 6 Overall response of the participants towards knowledge about water sector. The questions were related to knowledge about source of water, basic meaning of recycled water, and consumption of water in South Africa. Majority percentage was considered as 75% or above.

Questions	Options	Response percentage	Correct option	Majority (>75%) Correct?
What is your daily source of daily drinking water?	a) Tap	87.58%	Option (a)	Yes
	b) Bottled water	5.37%		
	c) Stream /river	2.01%		
	d) Bore hole	5.03%		
In your knowledge, which one of the below is recycled water?	a) Water taken from streams / rivers and then purified to make it fit for potable uses.	7.72%	Option (b)	No
	b) Wastewater from wastewater treatment works and then purified to make it fit for potable uses.	23.83%		
	c) Stored rainwater and then purified to make it fit for potable uses.	4.36%		
	d) All of the above	64.09%		
What is the main source of drinking water which is	a) Boreholes	2.01%	Option (b), (c) an	Yes
	b) Dam	47.32%		
	c) Rivers and streams	19.46%		

coming in your taps?	d) Seawater desalination	3.36%	d (e)	
	e) Treated water from reservoirs	27.85%		
Which sector is the biggest user of water in Durban?	a) Agricultural	45.30%	Option (a)	No
	b) Domestic use for people	15.10%		
	c) Industry	22.15%		
	d) No idea	17.45%		
Does Durban have sufficient water?	a) Sufficient water supply	24.50%	Option (b)	No
	b) Severe shortage	46.31%		
	c) No idea	29.19%		
A drinking water treatment plant has a source of water. This water is treated in the treatment plant and supplied in our houses through water distribution pipes. In your knowledge, which of the followings / are sources of water to a drinking water treatment plant?	a) Dams (fed by rivers)	55.03%	Option (a)	No
	b) Groundwater (water table below ground)	12.08%		
	c) Groundwater	1.68%		
	d) Industrial effluents	7.05%		
	e) Rivers	4.03%		
	f) No idea	20.13%		

4.9 PUBLIC ATTITUDE AND BEHAVIOUR TOWARDS POTABLE AND NON-POTABLE APPLICATIONS OF RECYCLED WASTEWATER

The public's attitude towards non-potable applications of recycled wastewater was examined by asking the willingness of the participants to adopt these applications. Four non-potable applications, watering gardens, flushing toilets, washing dishes, and washing clothes, were mentioned in the survey. The response percentage is shown in figure 4.1. All these non-potable applications were well accepted by the participants, with 43.6% strongly agreeing and 46%

agreeing with using recycled wastewater for the flushing toilets (Figure 4.1). Washing dishes was least preferred, with 11% of participants strongly agreeing and 49% agreeing. Combining strongly agree and agree response rates, it was observed that flushing toilets are mostly accepted (90%), followed by watering gardens (86%), washing clothes (68%) and washing dishes (60%).

The attitude towards potable applications of recycled water was evaluated by asking questions about willingness to use the water for swimming and drinking. The participants were reluctant to agree with the potable application of recycled wastewater (Figure 4.2). Only 5% of the participants selected the option of strongly agreed to swimming and drinking. The percentage of participants disagreed or strongly disagreed with using recycled wastewater for swimming and drinking was 28% and 33%, respectively. The willingness toward potable applications of recycled wastewater was relatively lesser than non-potable applications, indicating the requirement of proper distribution of applications for recycled wastewater.

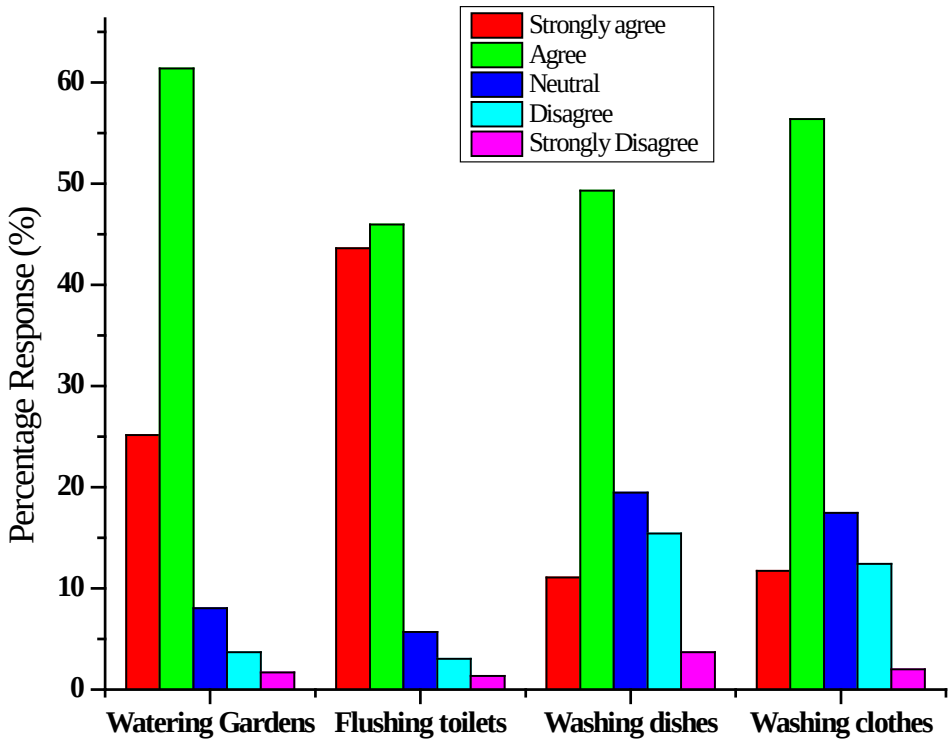


Figure 4. 1 Overall response towards acceptance of recycled wastewater for non-potable applications in households.

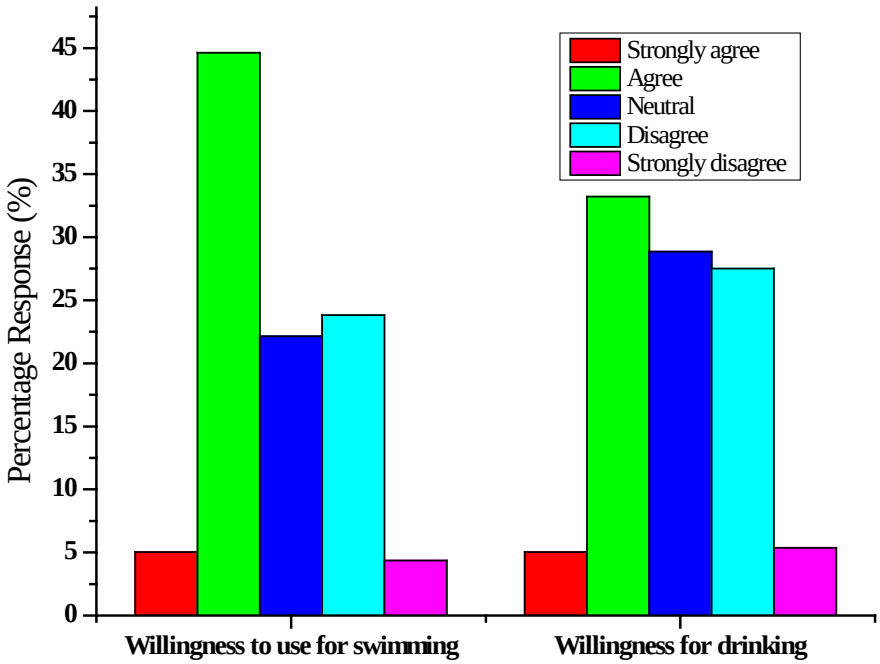


Figure 4. 2 Overall response towards acceptance of recycled wastewater for potable applications in households.

Participants' behaviour towards non-potable applications was assessed by asking questions in figure 4.3. The participants were asked about their willingness to consume food irrigated with recycled wastewater and buy a home using recycled wastewater for gardening and flushing toilets. The participants considered the latter option, with 87% of participants agreeing with the question and 56% of participants agreeing with consuming wastewater irrigated food. These findings are consistent with past research demonstrating that 92% of respondents agreed to use recycled water for irrigation. However, only 36% were confirmed for drinking water (Dolnicar *et al.,* 2011). A similar study finds that people used wastewater reuse for irrigation, landscaping and other uses that require minimal human contact. Around 15% of participants were willing to accept wastewater reuse for portable uses. The acceptance of wastewater reuse for various uses; showed 55% for clothes washing, 44% for showering/bathing and 24% for cooking (Massoud *et al.,* 2018). Also, 97% of respondents showed acceptance for firefighting (among least contact with people) and 69% for laundry (among household purposes), while 16% for consumption uses (Peters and Goberdhan, 2016). The observations imply that using decentralized wastewater reuse technologies and supplying recycled wastewater for watering and flushing gardens may be preferable in Durban. In addition, the observations may support the feasible operation of the centralized

recycling schemes with distribution networks for non-potable applications.

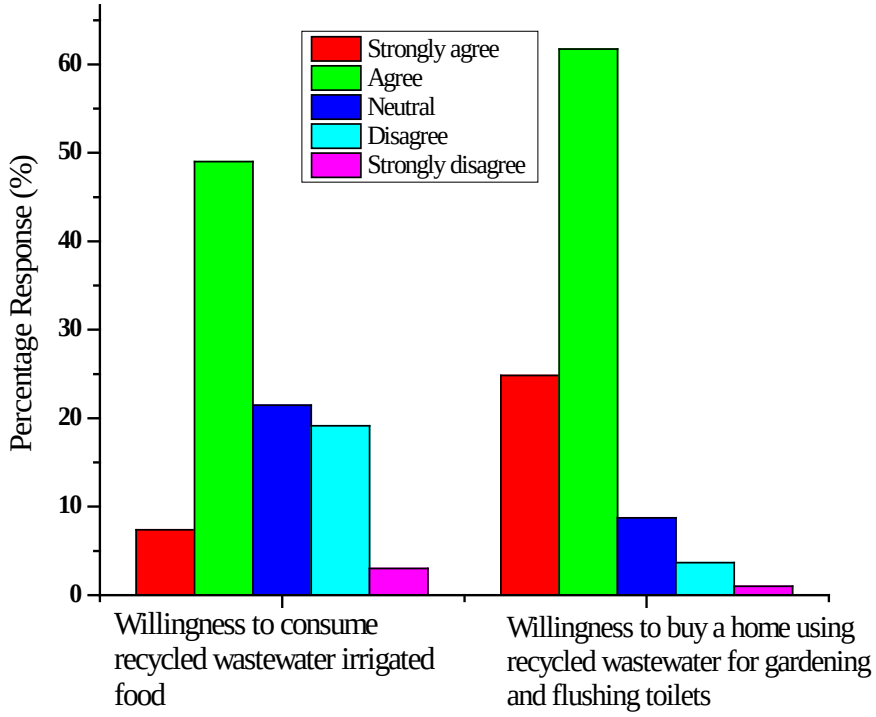


Figure 4. 3 Behavioural attitude towards acceptance of recycled wastewater for non- potable applications in households.

For the behavior assessment towards potable applications of recycled wastewater, the participants were asked a few questions, and the response percentage is shown in figure 4.4. Overall, the participants showed disagreement with protesting and complaining to the government about recycling water schemes. 38% of participants disagreed with protesting against the recycled wastewater scheme, and 33.6% disagreed with complaining to the government about recycling wastewater schemes. However, at the same time, the participants showed agreement with not drinking the recycled wastewater. The percentage of participants that agreed with not drinking the recycled wastewater was 42.3%, indicating the mixed perception of participants concerning wastewater recycling. Combining 'agree' and 'strongly agree' responses, 22% of participants agreed with protesting such recycling schemes. Such behavior can result in loss of capital and resources related to wastewater recycling schemes. In addition, such protests may attract another group of citizens who are not sure of their behavior or whose response was neutral in the survey. These types of participants were, 32% responded in favor of neutral behavior when asked about their intention to protest recycling wastewater schemes.

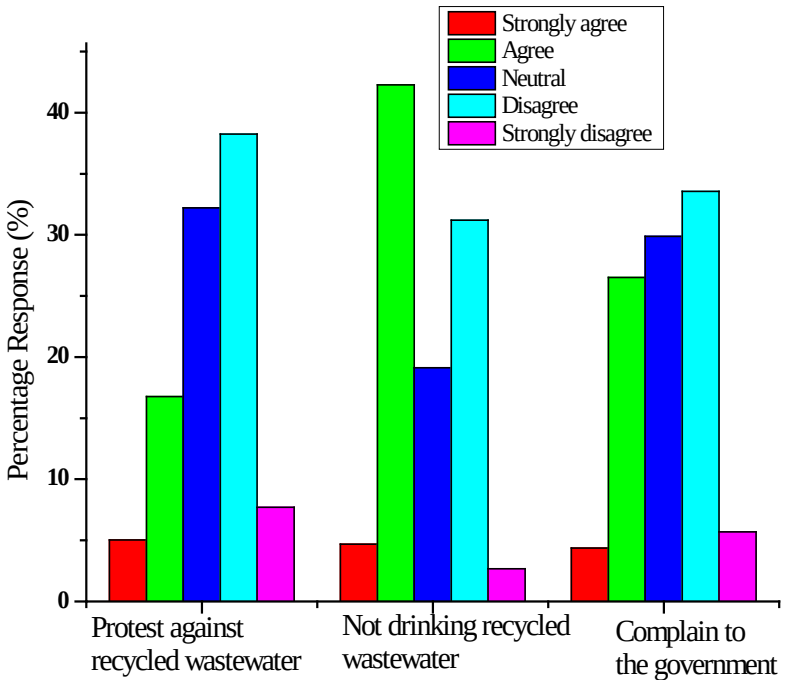
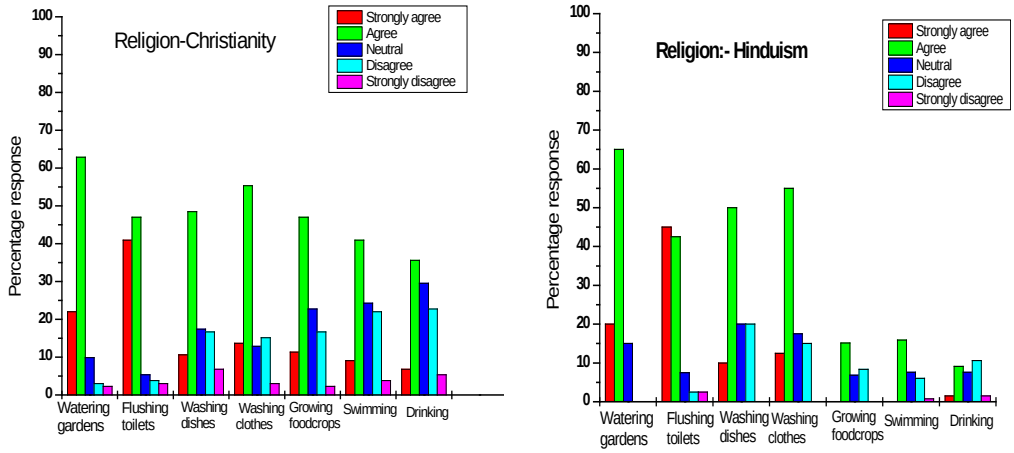


Figure 4. 4 Behavioural attitude towards acceptance of recycled wastewater for portable applications in households.

4.10 RELATIONSHIP OF RELIGION ON USAGE OF RECYCLED WASTEWATER



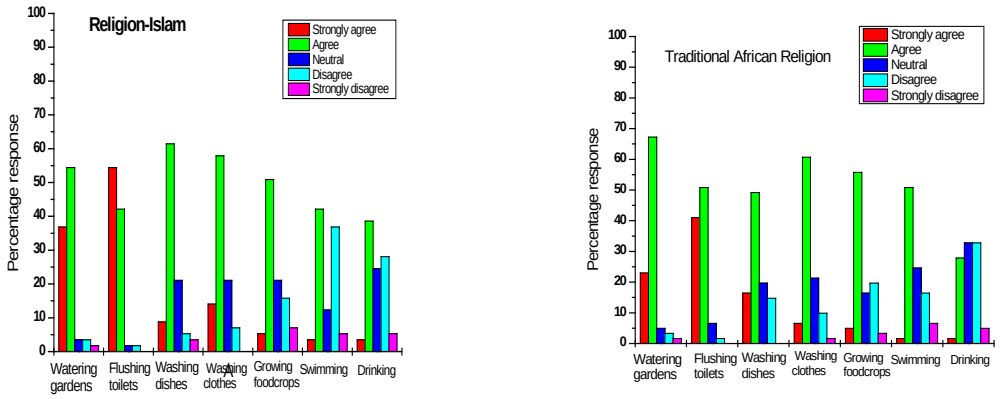


Figure 4. 5 Religion and level of willingness to use recycled wastewater for various applications in households.

The usage preference of recycled wastewater in various applications was related to religions, as shown in Figure 4.5. The non-contact applications of recycled wastewater, such as watering gardens and flushing toilets, were considered strongly by participants of all religions. The percentage of participants who agreed with using recycled wastewater for watering gardens was 85 - 91% (combined response percentage of strongly agreed and agreed) in all religions. In the case of flushing toilets, this percentage was 88-97%, with 88% from Christianity, 88% from Hinduism, 97% from Islam and 92% from traditional African religion. This indicates that the preference for using recycled wastewater for flushing toilets has no objection in any religious group. The percentage responses for 'strongly agree' and 'agree' decreased with an increase in the contact of the applications of the recycled wastewater. The acceptance of wastewater reuse for favorable applications among participants from all religions is highest for toilet flushing followed by watering gardens, then washing clothes washing dishes growing food crops, swimming and at last drinking. However, the preference percentage varied for some applications among participants from different religions. The percentage of participants agreeing to use recycled wastewater for swimming and drinking was 42 - 50% among Christians, 42 - 46% among Muslims and 42 – 46% among traditional African religions. However, the participants from Hinduism showed 11-16% agreement with swimming and drinking. The data overall suggested that all religious communities less consider direct contact applications of recycled wastewater. The difference in consideration level of recycled wastewater for direct contact applications among religious communities may suggest a need for community-wide engagement concerning implementing recycled wastewater for direct contact applications such as swimming and drinking.

4.11 TRUST FACTOR IN PUBLIC ACCEPTABILITY OF RECYCLED WASTEWATER

Trust in water authorities is among the main factors for accepting recycled wastewater (Gul *et al.,* 2021). To assess the level of trust in water authorities in Durban and investigate the possible reasons for the lack of trust, five trust statements and five possible factors were asked to the participants, as shown in Table 4.7. The responses were recorded on a scale of 5, ranging from strongly agree to strongly disagree. Regression coefficient analysis of the trust statements with the factors is shown in Table 4.7. The significance of the regression analysis, tested with a t-test, was good, with a $p<0.05$. Factors 1 and 4 showed positive regression (>0.5), with all four trust statements suggesting the lack of competence of local municipalities in managing water supply and lack of acting in the interest of public demands are the possible factors for the lack of trust among participants.

Table 4. 7 Correlation between concerns arising out of lack of trust in local municipality and the associated possible factors. The details of the various trust concerns and factor tested in this study are mentioned at the end of the table. All correlations are significant with $p<0.05$. Correlations of interest are shown in bold fonts.

	Trust concern 1	**Trust concern 2**	**Trust concern 3**	**Trust concern 4**	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
Trust concern 1	1.00							
Trust concern 2	0.61	1.00						
Trust concern 3	0.55	0.62	1.00					
Trust concern 4	0.55	0.62	**0.75**	1.00				
Factor 1	**0.57**	**0.59**	**0.62**	**0.67**	1.00			
Factor 2	0.34	0.37	0.46	**0.52**	0.49	1.00		
Factor 3	**-0.32**	**-0.32**	**-0.41**	**-0.44**	-0.47	-0.47	1.00	
Factor 4	**0.54**	**0.59**	**0.60**	**0.70**	0.64	0.54	-0.51	1.00

- Trust concern 1: - I have confidence that my local municipality will deliver satisfactory services.
- Trust concern 2: - I think that the local municipality has good intentions in managing Durban's water supply.
- Trust concern 3: - I can depend on the local water authority to provide a good quality water supply.
- Trust concern 4: - I have complete trust in the water authority to provide me with good quality water supply.
- Factor 1: - I agree that the local municipality is competent enough to manage our water supply.
- Factor 2: - The local municipality provides the Durban community with the necessary information they want to know about their water supply.

- Factor 3: - The local municipality does not listen to concerns raised by people like me.
- Factor 4: - I agree that the local municipality acts in the public interest when it comes to water quality.

This is consistent with the past research that people distrust the local municipalities and cannot handle, operate and supervise the process (Fielding and Roiko, 2014). People have trust issues with the government authorities (Peters and Goberdhan, 2016). Almost 90% of participants did not trust the authorities in operating and delivering the process (Massoud *et al.,* 2018). Factor 2 (providing necessary information about water) correlated significantly (Pearson coefficient 0.52) with trust statement 4 (Trust in the municipality to provide good quality water). This indicates that the local municipality should update citizens with the necessary information on water quality which will increase their level of trust among them. Factor 3 (not listening to people's concerns by the municipality) was negatively correlated with all trust statements (Table 4.7). This indicates that addressing people's concerns about water supply should be addressed precisely on time and satisfied. Any deficiency in this aspect may negatively impact the trust among the citizens and may influence the implementation of recycling wastewater schemes.

4.12 APPROACHES FOR PROMOTION OF RECYCLED WASTEWATER

There is a need to develop approaches to increase public acceptance of recycled water. A discounted water supply connection may motivate the public to accept recycled wastewater for portable applications. The participants considered discounted water bills as a condition for accepting recycled wastewater (Table 4.8). The response percentage was 44% in favour of discounted water bills, and 45% responded with the 'maybe' option. Gracia-Cuerva (2016) also reported that a reduced water bill increases the willingness to accept wastewater reuse. Financial incentives and reduced monthly costs on the water were found to help accept the wastewater reuse.

Table 4. 8 Preferences of the participants towards marketing strategy of recycled wastewater, which local authorities can adopt in future.

Parameter	Response (%)
Acceptance of recycled wastewater with a discounted water bill, as a condition	44% (Yes); 45% (Maybe); 11% (No)
Other benefit preferences to motivate acceptance of recycled wastewater	
Discount on income tax	16.40%
Shopping card rewards	19.80%
Cashback	17.10%
Discount on other municipality services	46.60%
Alternate preferences in absence of above benefits	
Accept with transparency and good customer care	60.70%
Bottled water	31.20%
Protest and complete rejection	6%
No preference	2%
Media choice for transparency and good customer care	
Facebook	47.7%
Whatsapp	44%
Instagram	2.3%
Twitter	4.7%
Snapchat	1.3%

Other preferences for benefits were asked of the participants, and 46.6% of participants considered a discount on municipality services as an alternative to the discounted water bill. Tariffs are used as a tool in managing drinking water demand. Marketers use tariffs to change the behaviour of consumers. The consumer decides whether to use less or pay more as tariffs increases. According to the study conducted by Adewumi *et al*. (2010), if the tariff for wastewater reuse is lower than the tariff for drinking water, 71% were willing to accept wastewater reuse.

On the contrary, if the tariff for wastewater reuse is higher, only 15% are willing. Further assessment of the marketing approaches was examined by asking participants about their response if no benefits were provided with the recycled wastewater scheme. The participants considered transparency in services and good customer care from the water authorities (61% response rate) as a condition for accepting recycled wastewater without any tangible benefits. The percentage of participants who considered switching to bottled water after implementing the recycled wastewater scheme was 31.2%.

The participants can achieve transparency and good customer care through various media platforms. The participants considered social media a platform for delivering information and customer services. The percentage of participants who considered Facebook and WhatsApp were 48% and 44%, while Twitter, Instagram and Snapchat were preferred by less than 5% of participants. This suggests that the local municipality should switch to modern media platforms to disburse water-related information and customer service. The focus with media platforms should be on water-related information and customer service. The local municipality got the social media handles; however, the content is mainly public notices with less focus on customer service and awareness. The preference of media platforms by the participants was the ease and subscription list of Facebook and WhatsApp.

4.13 STATISTICAL ANALYSIS

4.13.1 Demographic Statistics

The respondents' demographic characteristics were analyzed using frequency distribution (Table 4.9). The analysis shows that gender groups are fairly represented, with 133 males and 156 females. However, nine respondents "preferred not to say". It may be because they do not want to disclose their gender profile. Concerning the age group, 9.73% are less than 25 years, 30.20% in the range of 26-35 years, 36.58% in the range of 36-45 years, 20.81% in the range of 46-55 years and 2.68% are above 55 years. Regarding education, 2.01% opted "Never have been to school", 8.39% have gone to primary school, 14.77% high school, 41.61% have completed their bachelor's degree, and 33.22% had a postgraduate degree. Concerning Occupation, 15.10% were unemployed, 14.76% were Government employees, 27.51% worked in private companies, and 36.24% were found self-employed. Regarding religion, 44.63% were Christians, 13.42% were Hindus, 19.13% were Muslims, and 20.47% were found to have traditional African religions. Regarding Race, 7.05% were White, 63.42% were Black, 24.46% were Indian, and only 4.03% were found as Coloured. When asked about their monthly income, 19.13% of respondents were in the income level of R5000-R10000 per month. 39.59% were found in the level of R10000-R15000, and 29.19% had greater than R15000 per month. Regarding family members living with respondents, 13.42% were in the group of 1-2 members, 66.77% in the group of 2-5 members and 19.79% of respondents had greater than five members. A brief discussion of the socio-demographic characteristics is discussed in Table 4.9.

Table 4. 9 Background demographic details of the participants in Durban, South Africa. Descriptive Statistics

S.No.	Variable	Frequency	Percent
	Gender		
1	Male	133	44.63
2	Female	156	52.34
3	prefer not to say	9	3.02
	Total	298	100
	Age group		
1	<25	29	9.73
2	25-35	90	30.20
3	36-45	109	36.58
4	46-55	62	20.81
5	>55	8	2.68
	Total	298	100
	Education		
1	Never have been to school	6	2.01
2	Primary school	25	8.39
3	High school	44	14.77
4	Bachelor's degree	124	41.61
5	Post graduate degree	99	33.22
	Total	298	100
	Occupation		
1	Unemployed	45	15.10
2	Government	44	14.76
3	Private company	82	27.51
4	Self employed	108	36.24
5	Other	19	6.38
	Total	298	100
	Religion		
1	Christianity	133	44.63
2	Hinduism	40	13.42
3	Islam	57	19.13
4	Traditional African Religion	61	20.47
5	Other	6	2.01
6	Buddhist	1	0.34
	Total		
	Race		
1	White	21	7.05
2	Black	189	63.42
3	Indian	73	24.46
4	Colour	12	4.03

5	Arab	2	0.67
6	Australian	1	0.34
	Total	298	100
Monthly income			
1	<R5000	36	12.08
2	R5000-R10000	57	19.13
3	R10000-R15000	118	39.59
4	>R15000	87	29.19
	Total	298	100
Family members			
1	1-2	40	13.42
2	2-5	199	66.77
3	>5	59	19.79
	Total	298	100

4.13.2 Trust

Table 4. 10 Descriptive statistics of trust (TRU) construct.

	Variables							
	TRU-1		TRU-2		TRU-3		TRU-4	
	N	%	N	%	N	%	N	%
Strongly agree	22	7.4	24	8.1	22	7.4	23	7.7
Agree	165	55.4	165	55.4	151	50.7	133	44.6
Neutral	50	16.8	61	20.5	52	17.4	67	22.5
Strongly disagree	16	5.4	11	3.7	10	3.4	6	2.0
Disagree	45	15.1	37	12.4	63	21.1	69	23.2
Total	298	100.0	298	100.0	298	100.0	298	100.0
Mean	2.56		2.48		2.62		2.67	
Median	2		2		2		2	
Mode	2		2		2		2	
Standard Deviation	1.011		0.940		1.005		0.981	
Sample Variance	1.39		1.23		1.65		1.69	
Construct Mean	2.58							

One hundred and eighty-seven respondents (62.8 %) have agreed that they have confidence in the local municipality to deliver satisfactory services, while 61 (20.5%) do not trust the local municipality, as shown in Table 4.10. One hundred eighty-nine respondents (63.5%) believe that the local municipality has good intentions in managing Durban's water supply. One hundred seventy- three respondents (58.1%) agreed to depend on the water authority to provide a good quality water supply. One hundred fifty-six respondents (52.3%) trust the water authority to provide them with a good quality water supply. On the other hand, 47.7% of respondents are either neutral or disagree with trusting the water authorities. There is a direct relationship between trust and acceptance. The higher the trust in water authorities, the lower the risk perceptions and the greater the acceptance of wastewater reuse (Hurlimann *et al.,* 2008). Many factors can lead to distrust, such as handling problems, complaints, or past experiences. People distrust the local municipalities and cannot handle, operate and supervise the process (Fielding and Roiko, 2014).

People have trust issues with the government authorities (Peters and Goberdhan, 2016).

4.13.3 Past Experience

Table 4. 11 Descriptive statistics of past experiences (PE) construct.

	Variables							
	PE-1		PE-2		PE-3		PE-4	
	N	%	N	%	N	%	N	%
Strongly agree	14	4.7	3	1.0	11	3.7	13	4.4
Agree	141	47.3	103	34.6	94	31.5	128	43.0
Neutral	85	28.5	68	22.8	84	28.2	85	28.5
Strongly disagree	9	3.0	16	5.4	6	2.0	7	2.3
Disagree	49	16.4	108	36.2	103	34.6	65	21.8
Total	298	100	298	100	298	100	298	100
Mean	2.66		3.10		3.00		2.75	
Median	2.00		3.00		3.00		3.00	
Mode	2.00		5.00		5.00		2.00	
Standard Deviation	0.912		0.977		0.945		0.925	
Sample Variance	1.31		1.72		1.77		1.50	
Construct Mean	2.877							

Table 4.11 states that a total of 155 (52%) respondents believe that the local municipality is competent enough to manage water supply, whereas 58 (19.4%) respondents disagreed with it, and 85 (28.5%) respondents remained neutral. 106 (35.6%) respondents agreed that the local municipality provides the Durban community with the necessary information they want to know about their water supply. One hundred and twenty-four respondents (41.6%) disagreed that they were provided with the information. However, 105 participants (35.2%) stated that the local municipality does not listen to concerns raised by people like me. 140 respondents (47.4%) believed that local municipality acts in the public interest regarding water quality.

4.13.4 Attitude

Most of the respondents felt the risks linked with the recycled scheme. Table 4.12 presents 170 respondents (57%) agreed that there are possible problems

or risks associated with the recycling scheme and 167 respondents (56.1%) believed drinking recycled water poses a health risk. This was also confirmed by Massoud *et al*. (2018); around 60% of the respondents believed the wastewater reuse was both risky and unsafe and 60% perceived wastewater reuse as of inferior quality that may cause health risks.

One hundred twenty-seven respondents (42%) assumed that there is a lack of qualification, experience, and skilled operators in our municipality, which can result in the poor operation of the recycling technology, causing a health risk. The study also confirmed this; almost 90% of participants did not trust the authorities due to a lack of skillset in operating and delivering the process (Massoud *et al.,* 2018). Also, 217 (72.8%) respondents agreed that due to corruption in South Africa, a cheaper technology would be adopted in the recycled water project that will not be efficient in delivering safe drinking water. One hundred sixty-five participants (55.9%) assumed that customer complaints by the local municipality are not addressed well. Problems like poor water quality, aesthetics, and price concerns about recycled water will not be addressed. One hundred eighty respondents (60.4%) believed that local municipality lacks real-time interactions with the public and critical updates are delivered lately. So, there is always a perception of health risk in case of an accident at recycled water treatment works. A survey by Sydney Water (1999) regarding a water reuse scheme also found that 59% of respondents agreed with the statement that 'no one could guarantee the safety of recycled water.

Table 4. 12 Descriptive statistics of attitude (ATT) construct.

	Variables											
	ATT-1		**ATT-2**		**ATT-3**		**ATT-4**		**ATT-5**		**ATT-6**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Strongly agree	26	8.7	27	9.1	35	11.7	67	22.5	29	9.8	31	10.4
Agree	144	48.3	140	47.0	92	30.9	150	50.3	136	46.1	149	50.0
Neutral	69	23.2	68	22.8	87	29.2	54	18.1	57	19.3	55	18.5
Strongly disagree	5	1.7	6	2.0	6	2.0	5	1.7	4	1.4	3	1.0
Disagree	54	18.1	57	19.1	78	26.2	22	7.4	69	23.4	60	20.1
Total	298	100	298	100	298	100	298	100	295	100	298	100
Mean	2.56		2.58		2.76		2.15		2.60		2.51	
Median	2.00		2.00		3.00		2.00		2.00		2.00	
Mode	2.00		2.00		2.00		2.00		2.00		2.00	
Standard Deviation	0.942		0.965		1.032		0.912		0.994		0.961	
Sample Variance	1.50		1.56		1.85		1.10		1.78		1.65	

Construct Mean	2.52

4.13.5 Subjective Norm

Table 4.13 shows that one hundred and five respondents (35%) have agreed that religion allows for the use of recycled water. Most of the respondents have been neutral with this statement; maybe they do not have religious knowledge regarding the use of recycled water. One hundred thirty-eight participants (46.3%) believed the recycling scheme would be safe.

Table 4. 13 Descriptive statistics of subjective norm (SNO) construct.

	Variables			
	SNO-1		SNO-2	
	N	%	N	%
Strongly agree	12	4.0	25	8.4
Agree	93	31.2	113	37.9
Neutral	120	40.3	109	36.6
Strongly disagree	22	7.4	9	3.0
Disagree	51	17.1	42	14.1
Total	298	100	298	100
Mean	2.93		2.65	
Median	3.00		3.00	
Mode	3.00		2.00	
Standard Deviation	0.968		0.927	
Sample Variance	1.24		1.26	
Construct Mean	2.79			

4.13.6 Perceived Behaviour Control

Sixty-five respondents (21.8%) agreed they would protest purified recycled water being added to my drinking water. However, one hundred thirty seven respondents (46%) stated that they would not protest against this, as shown in Table 4.14.

One hundred forty respondents (47%) participants would not drink water that contained purified recycled water however, 33.9% of respondents agreed to drink the purified recycled water.

Ninety respondents (30.9%) would complain to the government if purified recycled water was added to their drinking water in the dam/ reservoirs, whereas one hundred seventeen respondents (39.3%) would not complain to the government if purified recycled water were added.

Table 4. 14 Descriptive statistics of perceived behavioural control (PBC) construct.

	Variables					
	PBC-1		PBC-2		PBC-3	
	N	%	N	%	N	%
Strongly agree	15	5.0	14	4.7	13	4.4
Agree	50	16.8	126	42.3	79	26.5
Neutral	96	32.2	57	19.1	89	29.9
Strongly disagree	23	7.7	8	2.7	17	5.7
Disagree	114	38.3	93	31.2	100	33.6
Total	298	100	298	100	298	100
Mean	3.27		2.85		3.10	
Median	3.00		3.00		3.00	
Mode	5.00		2.00		5.00	
Standard Deviation	0.996		1.005		0.99	
Sample Variance	1.65		1.87		1.70	
Construct Mean	3.07					

4.13.7 Intention

Two hundred fifty-eight respondents (86.6%) are willing to use recycled water for watering gardens and two hundred sixty-seven respondents (89.6%) were willing to use this water for flushing toilets, as depicted in Table 4.15. Also, 183 (61.4%) respondents are willing to use recycled water for washing dishes. Two hundred three respondents (68.1%) are willing to use recycled water to wash clothes. Two hundred and fifty eight respondents (86.5%) are willing to swim in water containing some recycled water. One hundred sixty-eight respondents (56.4%) said they prefer to consume food irrigated with recycled water. One hundred sixty-eight respondents (49.6%) would prefer to buy a home that uses recycled water for watering gardens and flushing toilets. The same results are further supported by Dolnicar *et al*. (2011), whereby 92% of respondents agreed they would use recycled water for irrigation. However, only 36% confirmed drinking water. A similar study finds that people used wastewater reuse for irrigation, landscaping and other uses that require minimal human contact. Around 15% of participants were willing to accept wastewater reuse for portable uses. Also, 97% of respondents showed acceptance for firefighting (among least contact with people) and 69% for laundry (among household purposes), while 16% for consumption uses (Peters and Goberdhan, 2016).

Table 4. 15 Descriptive statistics of intention (INT) construct.

	Variables													
	INT-1		**INT-2**		**INT-3**		**INT-4**		**INT-5**		**INT-6**		**INT-7**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Strongly agree	75	25.2	130	43.6	33	11.1	35	11.7	74	24.8	22	7.4	15	5.0
Agree	183	61.4	137	46.0	150	50.3	168	56.4	184	61.7	146	49.0	133	44.6
Neutral	24	8.1	17	5.7	58	19.5	52	17.4	26	8.7	64	21.5	66	22.1
Strongly disagree	5	1.7	5	1.7	11	3.7	6	2.0	3	1.0	9	3.0	13	4.4
Disagree	11	3.7	9	3.0	46	15.4	37	12.4	11	3.7	57	19.1	71	23.8
Total	298	100	298	100	298	100	298	100	298	100	298	100	298	100
Mean	1.95		1.73		2.50		2.37		1.94		2.61		2.78	
Median	2.00		2.00		2.00		2.00		2.00		2.00		3.00	
Mode	2.00		2.00		2.00		2.00		2.00		2.00		2.00	
Standard Deviation	0.794		0.834		1.003		0.916		0.757		0.975		1.007	
Sample Variance	0.73		0.77		1.46		1.27		0.71		1.54		1.65	
Construct Mean	2.26													

4.13.8 Behaviour

Table 4.16 shows that 153 respondents (51.3%) support adding purified recycled water to the water supply in the dam whereas, 132 (44.3%) participants did not want purified recycled water to be mixed with my drinking water. However,114 (38.2%) respondents agreed to drink the water provided by the recycling scheme. Gracia-Cuerva (2016) also asserts that 43% of the population supports reclaimed, and nearly half of the respondents (51%) showed a willingness to participate in programs that support the use of treated wastewater.

Table 4. 16 Descriptive statistics of behaviour (BEHV) construct

	Variables					
	BEHV-1		**BEHV-2**		**BEHV-3**	
	N	**%**	**N**	**%**	**N**	**%**
Strongly agree	20	6.7	24	8.1	15	5.0
Agree	133	44.6	108	36.2	99	33.2
Neutral	74	24.8	58	19.5	86	28.9
Strongly disagree	8	2.7	12	4.0	16	5.4
Disagree	63	21.1	96	32.2	82	27.5
Total	298	100	298	100	298	100
Mean	2.68		3.12		2.95	
Median	2.00		3.00		3.00	
Mode	2.00		2.00		2.00	
Standard Deviation	0.968		1.076		1.012	
Sample Variance	1.58		1.99		1.66	
Construct Mean	2.92					

INFERENTIAL STATISTICS

4.13.9 Normality

To measure the normality of various constructs, Skewness and Kurtosis were conducted with the help of SPPS v 20 (Statistical Software). Skewness and Kurtosis of all the variables were also measured, which fall in the range of -0.038 to 1.556 and -0.030 to 3.300, respectively, as shown in Table 4.17. Thus, all the variables fell within the threshold criteria of Skewness (-3 to +3) and Kurtosis (-8 to +8), validated by Kline (1998). Therefore, we can assume that the data is normally distributed.

Table 4. 17 Numeric Method illustrating Skewness and Kurtosis of the data

Construct items	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
TRU_1	298	1	5	2.56	1.011	.857	-.030
TRU_2	298	1	5	2.48	.940	.881	.344
TRU_3	298	1	5	2.62	1.005	.568	-.600
TRU_4	298	1	5	2.67	.981	.332	-.808
PE_1	298	1	5	2.66	.912	.597	-.235
PE_2	298	1	5	3.10	.977	.073	-1.193
PE_3	298	1	5	3.00	.945	.114	-1.008
PE_4	298	1	5	2.75	.925	.367	-.677
ATT_1	298	1	5	2.56	.942	.479	-.493
ATT_2	298	1	5	2.58	.965	.449	-.560
ATT_3	298	1	5	2.76	1.032	-.038	-.908
ATT_4	298	1	5	2.15	.912	.816	.598
ATT_5	295	1	5	2.60	.994	.339	-.879
ATT_6	298	1	5	2.51	.961	.465	-.682
SNO_1	298	1	5	2.93	.968	.373	-.260
SNO_2	298	1	5	2.65	.927	.332	-.151
PBC_1	298	1	5	3.27	.996	-.395	-.352
PBC_2	298	1	5	2.85	1.005	.187	-1.135
PBC_3	298	1	5	3.10	.999	-.115	-.767
INT_1	298	1	5	1.95	.794	1.343	3.142
INT_2	298	1	5	1.73	.834	1.556	3.300
INT_3	298	1	5	2.50	1.003	.677	-.174
INT_4	298	1	5	2.37	.916	.825	.319
INT_5	298	1	5	1.94	.757	1.175	2.734
INT_6	298	1	5	2.61	.975	.553	-.475
INT_7	298	1	5	2.78	1.007	.416	-.783
BEHV_1	298	1	5	2.68	.968	.399	-.646
BEHV_2	298	1	5	3.12	1.076	-.046	-1.085
BEHV_3	298	1	5	2.95	1.012	.121	-.805

4.13.10 Reliability and Validity Measures of Scale

Cronbach alpha (α) is used to measure the reliability of a summated scale by which several items are summed to form a total score (Kanya *et al.,* 2019). The co-efficient or Cronbach's alpha estimates the correlation coefficient of measurement items in a test. A co-efficient value varies from 0-1; a value of 0.5 or less is considered unsatisfactory. A 0.7 or above indicates high internal consistency or reliability (Bajpai, 2011). The results show that the value of α is more significant than 0.6, thus showing the scale's reliability as revealed in Table 4.18.

Table 4. 18 Scale reliability statistics of the constructs based on Cronbach's Alpha

Construct	**Cronbach's Alpha (α)**	**No of Items**
Trust	.865	4
Past Experiences	.813	4
Attitude	.775	6
Subjective Norm	.659	2
Perceived Behavioral Control	.783	3
Intention	.800	7
Behavior	.672	3

Table 4.19 depicts the results of KMO and Bartlett's Test of Sphericity. The KMO was found to be 0.888, indicating the correlations between variables were relatively high and satisfactory. The acceptable benchmark of value above 0.6 allows us to go ahead with confirmatory factor analysis. The Bartlett's Test of Sphericity results is also satisfactory, with an approximate chi-square of 4444.965 (p-value=0.000). Both these measures confirm the appropriateness of the data, and therefore confirmatory factor analysis can be done.

Table 4. 19 KMO and Bartlett’s Test of Sphericity

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.888
Bartlett's Test of Sphericity	Approx. Chi-Square	4444.965
	Df	406
	Sig.	.000

4.14 MEASUREMENT MODEL

Cluster Factor Analysis (CFA) measures the fit between theory and reality. The CFA aims to ascertain that it is a valid model. CFA is also called the non-directional model or Covariance model. All the constructs have been assumed as exogenous and non-causal bidirectional. The bidirectional relationship has been studied by drawing a double-headed arrow among the constructs, which represents the correlational relationship between variables. Circles and ovals represent latent variables, while squares and rectangles denote measured variables. CFA depends upon several fit indices like:

Normed Chi-Square Index (CMIN)

Goodness of Fit Index (GFI)

Adjusted Goodness of Fit Index (GFI)

Root Mean Square Residual (RMR)

Root Mean Square Error of Approximation (RMSEA)

These are known as indicators of absolute fit indices (Hu and Bentler, 1995).

Comparative Fit Index (CFI)

Tucker-Lewis Index (TLI)

Normed Fit Index (NFI)

These are referred to as indicators of incremental fit indices.

Parsimony Goodness of Fit Index (PGFI)

Parsimony Normed Fit Index (PNEI)

These are known as indicators of Parsimony fit indices.

The model shows the relationship between the independent and dependent variables (Behaviour). To assess the measurement adequacy between the various constructs; “Trust”, “Past Experience”, “Attitude”, “Subjective Norm”, “Perceived Behavioural Control”, “Intention” and “Behaviour”, a Confirmatory model has been used. The latent variables were TRU, PE, ATT, SN, PCB, INT, and BEHV. CFA model has been tested for fit and psychometric properties. The result of the CFA model reveals a good fit. The value of all indices such as Normed Chi-Square, GFI, AGFI, NFI, CFI, RMR and RMSEA meet threshold limits. The measurement model reveals a Normed Chi-Square Index = 2.86, GFI= 0.830, CFI= 0.865, SRMR= 0.074, RMSEA= 0.079, P close= 0.00, NFI= 0.809 (Table 4.20). All these indices were significant and specified a good model fit. Initially, the model showed weak values, so the model was redefined and

retested. Int_3, Int_4, Int_6 and Int_7 was deleted to get the final measurement model as presented in Figure 4.6. The model fits well after deleting these items.

Table 4. 20 Modified Model Fit Indices

Measure	**Estimated Value**	**Threshold Value (Hair *et al.,* 2014)**	**Comment**
CMIN (χ^2/df)	2.86	<3	Acceptable
GFI	0.830	≥0.800	Satisfactory
CFI	0.865	≥0.900	Acceptable
SRMR	0.074	≤0.08	Satisfactory
RMSEA	0.079	0.080	Acceptable
P close	0.00	>0.05	Acceptable

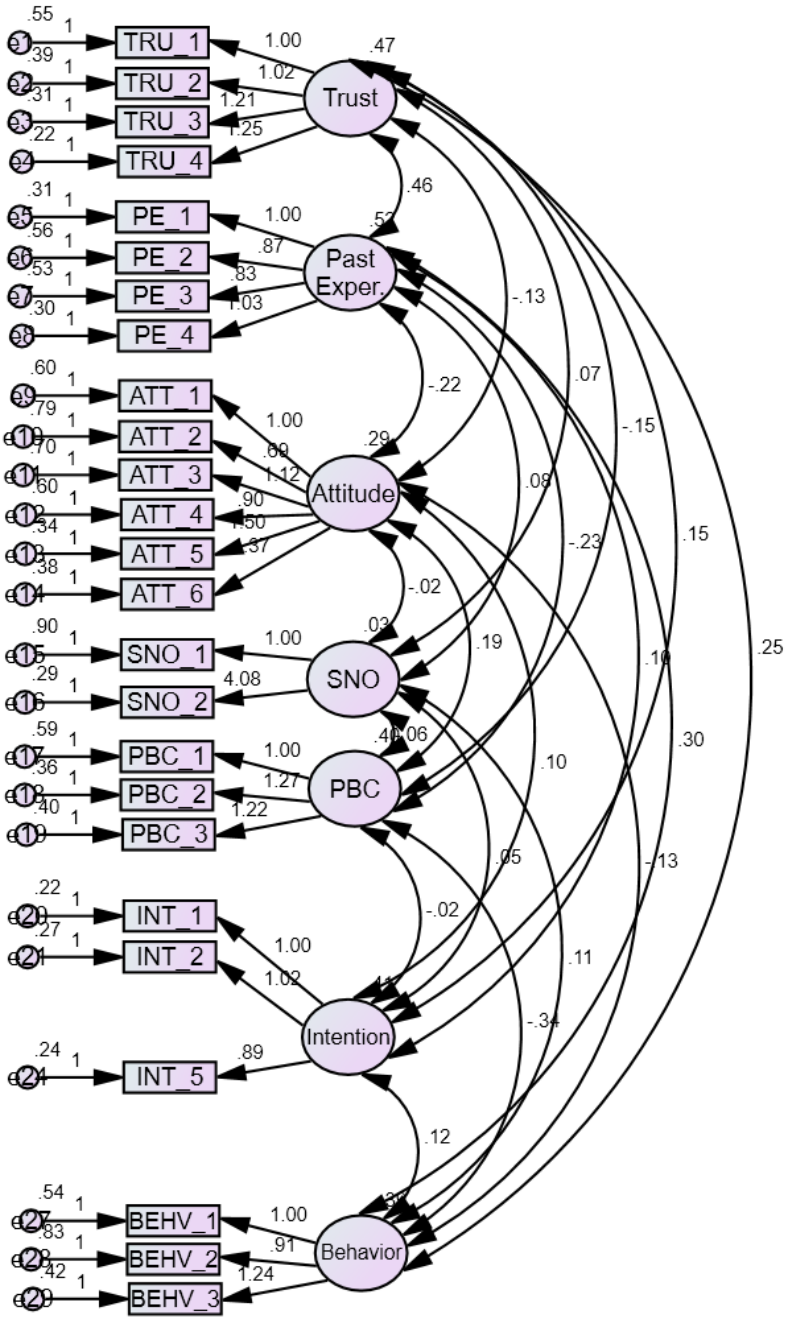


Figure 4. 6 Output measurement model in cluster factor analysis.

Table 4. 21 Average Variance Extracted and Composite Reliability after Factor Analysis

Construct		Factor loadings	AVE	CR
TRU	TRU_1	0.698		
	TRU_2	0.775		
	TRU_3	0.822		
	TRU_4	0.844	0.619	0.866
PE	PE_1	0.768		
	PE_2	0.801		
	PE_3	0.734		
	PE_4	0.773	0.592	0.853
ATT	ATT_1	0.762		
	ATT_2	0.758		
	ATT_3	0.754		
	ATT_4	0.856		
	ATT_5	0.744		
	ATT_6	0.827	0.615	0.905
SNO	SNO_1	0.855		
	SNO_2	0.804	0.688	0.815
PBC	PBC_1	0.714		
	PBC_2	0.814		
	PBC_3	0.791	0.599	0.817
INT	INT_1	0.800		
	INT_2	0.803		
	INT_3	0.746		
	INT_4	0.818		
	INT_5	0.863		
	INT_6	0.727		
	INT_7	0.695	0.610	0.916
BEHV	BEHV_1	0.776		
	BEHV_2	0.701		
	BEHV_3	0.892	0.730	0.835

After measuring the reliability and validity of the scales, Cronbach alpha, composite reliability (CR) and Average Variance Extracted (AVE) were calculated. All the values are recommended to be above 0.5 (Hair *et al.,* 2014; Bajpai, 2011). The result from the Table 4.21 depicts that the factor loadings of all constructs were above the threshold value of 0.5. the AVEs of all constructs were above 0.5. The results reveal convergent validity in all the constructs in the model.

4.15 INTER-CORRELATION BETWEEN CONSTRUCTS

Table 4.22 reveal strong and positive correlations between the various constructs. For example, there is a positive and strong correlation between TRU and ATT (r=0.855; p<0.01), PE and ATT (r=0.758; p<0.01), ATT and INT (r=0.799; p<0.01), SNO and INT (r=0.722, p<0.01), PBC and INT (r=0.655, p<0.01), PBC and BEHV (r=0.854, p<0.01) and INT and BEHV (r=0.809) respectively. These seven relationships measured the behaviour to accept or reject wastewater reuse.

Table 4. 22 Inter Correlations between Constructs

	TRU	**PE**	**ATT**	**SNO**	**PBC**	**INT**	**BEHV**
TRU	**1.00**						
PE	.925	**1.00**					
ATT	.855	.758	**1.00**				
SNO	.846	.815	.740	**1.00**			
PBC	.747	.603	.674	.623	**1.00**		
INT	.934	.805	.799	.722	.655	**1.00**	
BEHV	.794	.656	.694	.945	.854	.809	**1.00**
All correlations are significant at the 0.01 level							

4.16 STRUCTURAL EQUATION MODELLING

The SEM is an important part of the modelling process, showing how the latent variables are related. SEM helps us to measure the measurement properties and test the proposed theoretical relationships using a single technique. It consists of both a measurement model and a structural model. The latent variables were TRU, PE, ATT, SN, PCB, INT, and BEHV. After CFA, the data were analysed using the two-step approach to SEM. The first step is analysing the measurement model to establish the relationship between the latent variables and the observed indicators. The second step involved analysing the hypothesised structural model. The items of the scale are the indicators in the measurement and structural models (Ross *et al.,* 2014). The SEM allows the researcher to test the hypotheses and conceptual model empirically. It is also called Path analysis, Structural model or Causal model. The model indicated that all item loadings were significant (p <.001), and all the indices met the threshold limit. The indices indicate whether the established SEM reflects the data and is reliable. Otherwise, poor indices render the results unreliable (Kang and Ahn, 2021). Thus, these

indicator variables were accepted to use in the structural model. The results from the various indices from the structural model are shown in Table 4.23.

Table 4. 23 Structural Model Fit Indices

Measure	Estimated Value	Threshold Value (Hair *et al.*, 2014)	Comment
CMIN (χ^2/df)	2.92	<3	Acceptable
GFI	0.809	≥0.800	Acceptable
RMSEA	0.078	≤0.080	Acceptable
IFI	0.948	≥0.900	Acceptable
CFI	0.947	≥0.900	Acceptable
TLI	0.928	≥0.900	Acceptable

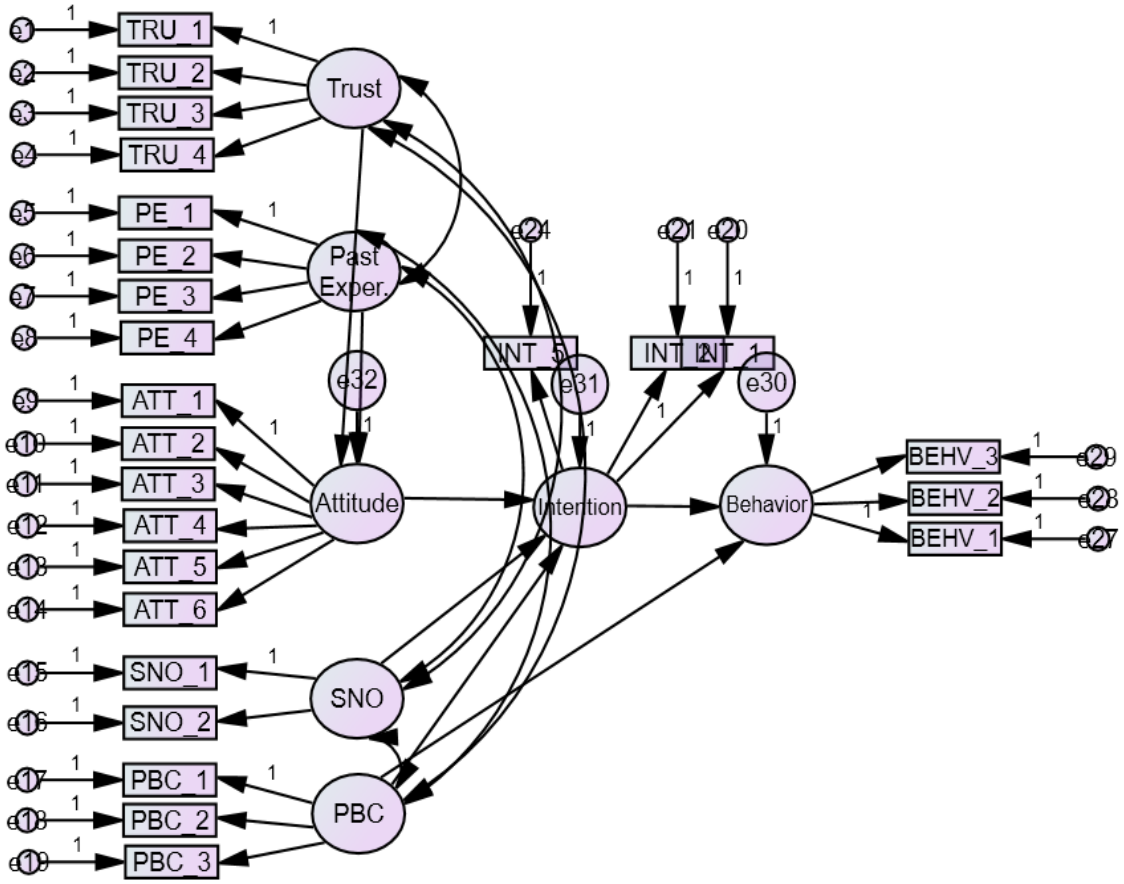


Figure 4. 7 Input path diagram in structural equation modelling.

It is evident that ATT, SNO and PBC predict Intention (INT), and INT, in turn, predicts BEHV, as shown in Figure 4.7. Also, PBC is inversely related to BEHV. Two latent variables, INT and PBC, have a significant relationship with BEHV. TRU, ATT, SNO and PE did not have a significant direct relation to BEHV.

However, it had a significant effect on INT and thereby resulting in an indirect influence on BEHV.

4.15 REVISED MODEL CONFIRMING HYPOTHESES

4.15.1 Revised Model

The simplified schematic of the standardised path co-efficient, β, of the hypothesised model is shown in Figure 4.8. A strong contribution (β value) is more significant than 0.40; a moderate contribution ranges from 0.20 to 0.40, and a weak contribution is a value less than 0.20 (Table 4.24).
Also, no causal relationship was found between SNO, PBC and ATT.
No direct relationship between Trust and Intention was found.
PBC and INT have a direct causal relationship with BEHV.

Table 4. 24 Confirmation of hypothesis by relationships of path analysis of endogenous and exogenous variables. Standardized Estimate (β) with Standard Error (S.E), and t-values (Critical ratios CR), and p-values.

Independent variable		**Dependent variable**	**Standardized Estimate (β)**	**S.E.**	**C.R.**	**P**	**Hypothesis**
PE	→	ATT	0.381	0.052	3.42	***	Accepted
TRU	→		0.442	0.058	3.47	***	Accepted
ATT	→	INT	0.581	0.062	3.08	.009	Accepted
SNO	→		0.343	0.054	2.43	.011	Accepted
PBC	→		-0.043	0.081	2.47	.004	Accepted
INT	→	BEHV	0.731	0.086	3.42	***	Accepted
PBC	→	BEHV	-0.084	0.065	3.31	***	Accepted
Significant at the 0.01 level							

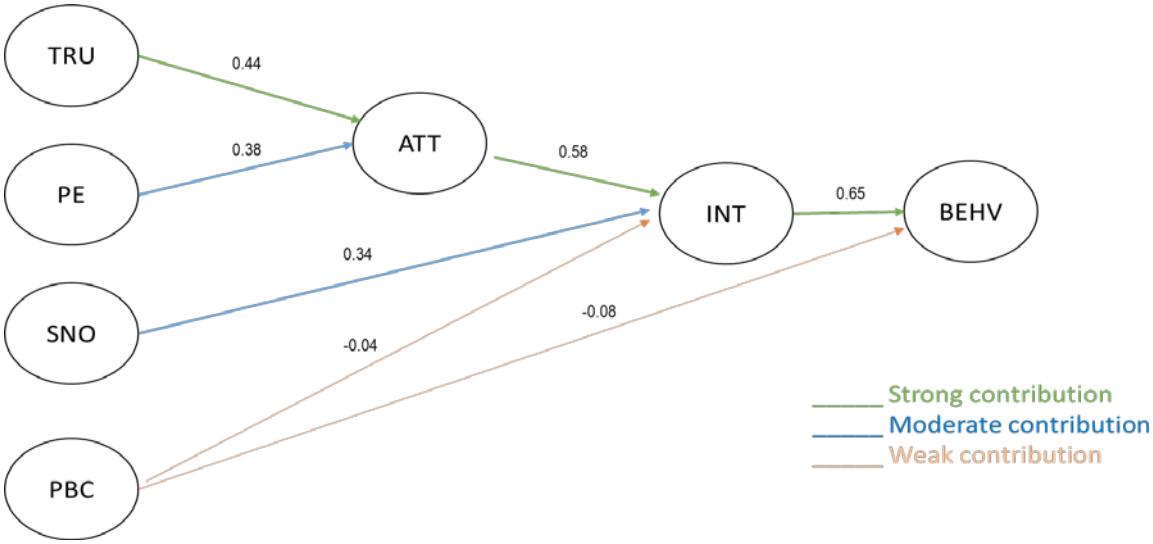


Figure 4. 8 Revised Model with simplified path coefficients

4.15.2 Confirming Hypothesis one

Trust and attitude: It was assumed that respondents' trust in the wastewater authorities positively affected their attitude toward accepting wastewater reuse. This is consistent with the findings of Nancarrow *et al*. (2009) and Adewumi *et al*. (2014) that trust contributes to respondents' intention to accept wastewater reuse. Also, Nancarrow *et al*. (2008) believe that trust in authorities directly leads to lower perceived risks of wastewater reuse. Another study found that the higher the trust in water authorities, the lower the risk perceptions and the greater the acceptance of wastewater reuse (Hurlimann *et al.,* 2008). From the path analysis, H1 is therefore accepted (p-value is significant), resulting in trust in the wastewater authority that can help create a positive attitude.

4.15.3 Confirming Hypothesis two

Past experience and attitude: It was hypothesised that past experience from the service providers positively impacts the attitude. It indicated that the excellent experience the respondents had in the past directly impacted their attitude. The work and credibility of the service providers influence the attitude accordingly. Therefore, H2 is accepted as the values are significant. This is in line with Ross *et al.* (2014) that the more credible the water authorities are, the more people trust them.

4.15.4 Confirming Hypothesis three

Attitude and intention: It were presumed that the respondent's positive attitude towards wastewater reuse significantly influences the intention to accept the wastewater reuse. From the path analysis, the values are found to be significant. Thus, H3 is accepted. The results are supported by Adewumi *et al*. (2014), that attitude is a strong contributing factor to the intention to accept wastewater reuse.

4.15.5 Confirming Hypothesis four

Subjective norm and intention: It was assumed that higher subjective norms associated with wastewater reuse positively impact the intention to accept the wastewater reuse. From the results, H4 is accepted as the values are significant. This is supported by the assertion of Nancarrow *et al*. (2008) that there is a significant relation between subjective norm and intention and moderate correlation (Nancarrow *et al.,* 2009). According to Adewumi *et al*. (2014), subjective norms moderately contributed to respondents' intention to accept wastewater reuse.

4.15.6 Confirming Hypothesis five

Perceived behavioural control and intention: PBC had a negative effect on INT (β= -0.04); it shows a weak contribution towards intention. This means respondents who perceived a greater PBC had more negative intentions toward wastewater reuse. Therefore, H5 is rejected. These outcomes align with Po *et al*. (2004) that the respondents who perceived more significant control over their drinking water source had a more negative attitude towards indirect potable reuse. They were less likely to drink this water.

4.15.7 Confirming Hypothesis six

Perceived behavioural control and behaviour: PBC had a negative effect on BEHV (β= -0.08), although it shows a weak contribution towards behaviour. This means respondents who perceived a greater PBC show more negative behaviour towards accepting wastewater reuse. Thus, H6 is rejected. These findings are consistent with the outcomes of Po *et al*. (2004) that the respondents who perceived more significant control over where and how their vegetables are grown were more pessimistic about buying the vegetables grown with recycled water. They were less likely to buy these vegetables.

4.15.8 Confirming Hypothesis seven

Intention and behaviour: It were assumed that intention positively and significantly impacts the behaviour to accept wastewater reuse. Intention to use the recycled water directly contributes to the acceptance of wastewater reuse. Intention plays a vital role in accepting wastewater reuse (Nancarrow *et al.,* 2008; 2009; Adewumi *et al.,* 2014; Ross *et al.,* 2014).

4.16 FINDINGS AND DISCUSSION EMANATING FROM RELIGIOUS FAITHS

A separate unstructured and open-ended questionnaire was provided to local religious councils to evaluate the public perception of using recycled water. This study aimed to understand the religious views towards wastewater reuse and their interest in motivating the public towards the acceptance of recycled water. Durban is the home adherent of many faiths (Wilson and Pfaff, 2007). Religious

distribution in KZN includes the main religions as 79% Christianity, 2% Muslim and 4% Hindu (StatsSA, 2019). The responses from each organisation are attached in Appendix 7.

Key findings from the Islamic Organisation "Jamiat-ul Ulama KZN" clearly show unacceptance towards the wastewater reuse for drinking, washing and bathing. However, they will prefer to reuse water for gardening and other outdoor uses where minimal human contact exists. The organisation mentioned that they would not participate, motivate, or encourage people towards the acceptability of the recycling programs. They believe that water conservation and water harvesting as the best options. Similar studies show that around 20% of the respondents believed wastewater reuse was religiously unacceptable. Most of the total respondents believed that it is repulsive and unhygienic to use this water that was once contaminated with human waste (Masoud *et al.,* 2018).

However, one of the reports given by Jamiat of South Africa mentioned that after recycling wastewater, one can use the water for potable uses. Also, no religious restrictions were found on the consumption of recycled water (Wilson and Pfaff, 2007). This means a lot needs to be done on the ground. Firstly, the religious bodies must be informed, and then intensive public awareness campaigns (Muazu *et al.,* 2020) can be conducted.

The representative of the Hindu faith, "South African Hindu Maha Sabha," stated that they will accept the wastewater reuse for gardening, washing, outdoor activities, bathing and even drinking. They firmly believe that recycled wastewater schemes are essential for growing water demand and that stress on existing water sources is due to climate change. Water is very sacred to them. They believe water is necessary for life and purifies the heart, mind, body and soul. They also stated that there are no specific criteria that restrict members of the Hindu community from making use of recycled water. Socio-cultural concerns may arise; however, on the side of Hindu dogma, preserving, nurturing, and ensuring sustainable water usage remains a top priority. They believed that water purification and recycling are also mentioned in their famous scripts "Atharvaveda Samhita x-5-24." However, they refused to participate in or promote the campaigns for the acceptability of wastewater reuse. Some temples in India have been using rainwater harvesting systems and wastewater recycling to achieve sustainable water usage. They stated that campaigns and unity among communities are the key points to promoting water recycling.

The Christian organisation was reluctant to answer the various questions. The organisation is 110 years old. They stated that recycled water could be used only for gardening. They cannot be used for washing, bathing, drinking or outdoor activities. They strongly disagree that recycled wastewater schemes are important for growing water demand and stress on existing water sources is due to climate change. They refused to participate in or promote the campaigns for the acceptability of wastewater reuse.

4.17 DISCUSSION ON WASTEWATER RECYCLING AND RELIGIOUS FAITHS

Many studies have been carried out so far concerning the Islamic faith (Crook *et al.,* 2005, Wilson and Pfaff, 2007, Muanda *et al.,* 2017, Muazu *et al.,* 2020). However, there is, unfortunately, no study that confers a link between wastewater reuse and other religious faiths. Therefore, it indicates that future research should be carried out to study, evaluate, and assess these communities' perceptions.

Islamic teachings was considered one of the barriers for Muslims to reuse wastewater. Water recycling schemes are common in several Muslim-majority countries like Kuwait, Syria, Iran, and Saudi Arabia. The percentage of treated wastewater in the Arab regions is 54% higher than in Asia (35%). Arab nations are the leaders in wastewater recycling and reuse (Crook *et al.,* 2005). They have played a vital role in the improvement of innovative water solutions.

Saudi Arabia has also issued a *fatwa* (Islamic ruling) regarding water reuse in agriculture, recreation, and ritual use. Muslims in South Africa (Durban) resisted and protested the wastewater reuse when the eThekwini municipality announced using reclaimed water to supplement the existing potable water supply in 2012. The community claimed the reuse of water as unclean and un-Islamic. Similar findings were reported by Muanda *et al*. (2017) in South Africa that Muslim leaders indicated hesitation in adopting reclaimed water. However, religious scholars' proper analysis showed that reclaimed wastewater is not prohibited in Islam (Muanda *et al.,* 2017). Masoud *et al*. (2018) found a significant relationship between religious beliefs and respondents' willingness to accept wastewater reuse. The people who showed unacceptance of wastewater reuse based on religious beliefs were twice less than those who accepted the wastewater on a religious basis. According to the study by Wilson and Pfaff (2007), there are no religious conflicts regarding the acceptance of recycled wastewater locally and internationally. The organisation of the Eminent Scholars of Saudi Arabia, an eminent Muslim organisation, has also approved reusing wastewater for religious applications (Faruqui *et al.,* 2001).

According to the Islamic faith, water's purity and impurity depend upon water quality. The Islamic Jurisprudence says a slight change in the colour, taste and smell is considered contaminated. According to the Islamic Jurisprudence (Fiqh-us-Sunnah), if the impurity changes the taste, colour, or odour of the water, it is considered as contaminated and cannot be used for purification. According to Ibn al-Mundhir (al-Aswat 1/260), all the scholars are agreed upon that the water is not fit for the purpose of wudoo or ghusl (ablutions), if impurity falls into the water, whether small or great amount and that impurity changes the taste, colour or smell of water.

However, the impurity can be diluted, and things can change their form, called complete metamorphosis (Wilson and Pfaff, 2007). In the Islamic faith, water is classified into three groups: *Tahur*, *Tahir* and *Mautanajjis.* The first category Tahur is pure natural water which may be used for religious and mundane purposes without any treatment. In the second category, Tahir cannot be used for religious but mundane purposes without any treatment. Both these types become mautanajjis when they are contaminated with pollutants like urine or faecal matter and make them unfit for religious and mundane purposes. However, it can be used for irrigation (Farooq and Ansari, 1983). According to the Hindu faith, God lives through five elements: sky, fire, wind, earth, and water. Concerns for the poor health of the environment were expressed. Problems with polluted and impure water were also discussed. According to the Christian faith, wastewater reuse was not a spiritual issue but a practical issue. The Buddhist faith confers the standards and procedures used in recycling and its maintenance over time. According to them, an open, honest, and fair process is critical (Wilson and Pfaff, 2007). In summary, religion is a location-specific barrier that cannot be ignored, and a proper approach to support from religious knowledge can be a strategic approach to deal with it. The literature about public acceptance of reclaimed wastewater in major global religious sectors such as Christians, Hindus, and Buddhists is not available, indicating that future research directions should be carried out to evaluate and assess these communities' perceptions.

4.18 CONCLUDING SUMMARY

This chapter presents the demographic differences, one-way ANOVA across the acceptance and the various socio-demographic factors. It briefly explains the role of knowledge, trust and religious beliefs in accepting wastewater reuse. It highlights and discusses the various promotional approaches suggested by respondents.

This chapter further highlights the findings and interpretations of the study. The data was analysed using SPSS v 22.0 and AMOS v 24.0 software. Descriptive Statistics is explained in the first section and is followed by statistical analysis. The validity and reliability of the measurement scale are measured and interpreted. Confirmatory factor analysis and Structural Equation Modelling is briefly explained and discussed in this chapter. This section consists of measurement modelling and hypothesis testing.

The last chapter highlights the conclusion drawn from the research findings, recommendations, and suggestions for future research studies.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

This concluding chapter is positioned to make a substantial contribution to the field of recycling of wastewater recycling and public perception. A comprehensive review of literature was conducted, and quantitative methodologies were employed to identify the behaviour towards the acceptability of wastewater. This section presents the summary of the work, findings, conclusion and suggestions, and recommendations for future research.

5.2 OVERALL CONCLUSIONS FROM THE STUDY

This study is positioned to make a very significant contribution to existing literature. It undertakes the theory of Planned Behavior and other new variables and identifies the link between them to examine the public perception of accepting wastewater reuse. Several studies suggest that public acceptance of wastewater reuse is the product of various factors. Nancarrow *et al*. (2009, 2010) and Po *et al*. (2005) found that public acceptance is a product of attitude, emotion, perceived behaviour control, subjective norms, knowledge, risk, trust, cost, and water scarcity and socio-demographic factors. Adewumi *et al*. (2104) assumes that the predicted intention to accept the wastewater is influenced due to the various factors like advantages of reuse, trust, attitude, perceived behaviour control, subjective norm, and physical quality satisfaction. However, in the previous studies, physical quality satisfaction and subjective norm could not be measured because of the lack of reliable scales. In line with these studies, the present work was conducted to identify and evaluate the factors that impact the intention to accept wastewater reuse and develop a model system to understand the behavior of the public towards the reuse of wastewater. The proposed framework may help identify what is more important to people in their decisions to accept wastewater reuse. The role of knowledge and marketing strategies were identified and evaluated. It can help the decision-makers address the various factors predicting intention to accept wastewater reuse before implementation. A comprehensive literature review was done, and quantitative research methodologies were used to develop insights from the study. The study followed a descriptive research design and involved a survey method as the data collection method. Structured and self-administered questionnaires were used to collect data. The primary data collected from 298 respondents was analyzed through Microsoft Excel, SPSS v 22, and AMOS v 24 statistical packages. The statistical techniques include exploratory factor analysis, confirmatory factor analysis, reliability and validity tests, and structural equation modelling. The results involved the main constructs, trust, attitude, subjective norm, past

experience, perceived behavioral control, intention and behavior, to identify how the public perceives wastewater reuse and how the acceptance or rejection was linked to these variables.

5.3 KEY FINDINGS

The significant findings, suggestions and limitations are discussed in this chapter.

- Only 23.8% knew about recycled wastewater, and most people did not know about recycled wastewater. This indicates the need to educate citizens of Durban about water-related aspects.
- Less than half of the respondents (46.3%) were knowledgeable about water scarcity in Durban, 24.5% responded that there is sufficient water, and 29.2% responded with having no idea about the water scarcity in Durban. Unless there is a realization of water scarcity in a region, the citizens may find it challenging to adopt alternate water supply from recycled wastewater.
- Public attitude and behavior towards potable and non-potable applications of recycled wastewater, it was observed that flushing toilets are accepted chiefly (90%), followed by watering gardens (86%), washing clothes (68%) and washing dishes (60%). The willingness towards potable applications of recycled wastewater was relatively lesser than non-potable applications, indicating the requirement of proper distribution of applications for recycled wastewater.
- The participants were asked about their willingness to consume food irrigated with recycled wastewater and buy a home that uses recycled wastewater for gardening and flushing toilets. The participants considered the latter option, with 87% of participants agreeing with the question and 56% of participants agreeing with consuming wastewater irrigated food.
- The favourable applications among participants from all religions followed the order of toilet flushing> watering gardens> washing clothes> washing dishes> growing food crops> swimming> drinking. However, the preference percentage varied for some applications among participants from different religions. The percentage of participants agreeing to use recycled wastewater for swimming and drinking was 42 - 50% among Christians, 42 - 46% among Muslims and 42 – 46% among traditional African religions. However, the participants from Hinduism showed 11-16% agreement with swimming and drinking. The data overall suggested that all religious communities less consider direct contact applications of recycled wastewater.
- Regarding the trust, the lack of competence of local municipalities in managing water supply and the lack of acting in the interest of public demands are the possible factors for the lack of trust among participants.

- As per the marketing strategies, the participants considered discounted water bills as a condition for accepting recycled wastewater. Other preferences for benefits were asked of the participants, and 46.6% of participants considered a discount on municipality services as an alternative to the discounted water bill.
- Further assessment of the marketing approaches was examined by asking participants about their response if no benefits were provided with the recycled wastewater scheme. The participants considered transparency in services and good customer care from the water authorities (61% response rate) as a condition to accept recycled wastewater without any tangible benefits. The percentage of participants who considered switching to bottled water after implementing the recycled wastewater scheme was 31.2%.
- The participants considered social media a platform for delivering information and customer services. Facebook and WhatsApp were preferred social media for disseminating the information to customers.
- Respondents' trust in the wastewater authorities positively affects their attitude to accepting the wastewater reuse. Also, past experience from the service providers positively impacts the attitude.
- Respondents' positive attitude toward wastewater reuse significantly influences the intention to accept the wastewater reuse.
- Higher subjective norms associated with wastewater reuse positively impact the intention to accept wastewater reuse. Respondents' perceived control over the water source and its application negatively affect the intention to accept wastewater reuse. They also perceived that control over the water source and its application indirectly influence the behaviour to accept wastewater reuse.
- Finally, the intention positively and significantly impacts the behaviour to accept wastewater reuse. Intention to use the recycled water directly contributes to the acceptance of wastewater reuse.

5.4 CONTRIBUTION TO KNOWLEDGE

This is the first study that has linked many variables like trust, experience, attitude, subjective norm and perceived behavioural control to predict the intention towards the acceptability of wastewater reuse and to develop a model system to understand the behaviour of the public towards the reuse of wastewater. Several studies have been conducted to evaluate the intention to accept wastewater reuse; however, there have been no empirical studies conducted in South Africa for some important factors. Also, the role of religious beliefs was analyzed and discussed briefly. An important contribution to the literature is that this study found that these factors have a positive impact on the intention to accept wastewater reuse. Also, trust does not directly affect the

intention but through attitude. Specifically, the study has contributed to the body of literature by finding that trust and experience both affect the attitude that affects the intention. The attitude and subjective norm directly and positively impact the intention. The study developed a framework of factors that impact the intention and affect the behavior. The framework is an important and useful tool for predicting public perceptions of the acceptability of wastewater reuse. Decision-makers or strategists can use the model to devise and craft the strategies before implementing the projects and schemes.

5.5 RECOMMENDATIONS

Several studies have been conducted so far to get the level of acceptance concerning both potable and non-potable uses. Many factors have been identified and evaluated to understand the acceptance of wastewater reuse. However, there is still much opposition to accepting this water.

- People who have much knowledge still resist using recycled wastewater. The public should be provided with the education and information on recycling wastewater reuse benefits and risks to achieve both environmental protection and sustainable development (Bakopoulou and Kunglos, 2009).
- There is a need to engage the public in the decision-making of wastewater reuse schemes instead of informing them about the final decisions (Massoud *et al.,* 2018) and make people aware of the benefits and processes of recycled wastewater. Intensive public awareness campaigns (Muazu *et al.,* 2020.). Strategists and decision-makers should use the information to devise appropriate and sustainable management strategies.
- After finding the significant relationship between tariffs and acceptability, government authorities should implement tariffs and financial incentives (Adewumi *et al.,* 2010). There is a lot of distrust and risk associated among the public with the acceptance of wastewater reuse. Building public trust and proper communication channels (Massoud *et al.,* 2018) can increase public acceptance.
- Proper training for the personnel (Alhumoud *et al.,* 2003) and proper guidelines and regulations for reuse can be the solution to increase the acceptability (Adewumi *et al.,* 2010). Implementation programs should be there (Peters and Goberdhan, 2016), with the focus on substantial social acceptability (Gracia Cuerva, 2016).
- Political vote banks impact the water reclamation initiatives, and predominantly the opposition is triggered by political parties ruling in opposition. Relaxing taxes or exempting reclaimed water users can encourage users to adopt reclaimed water. A ruling political party amid corruption controversies can negatively impact users' trust. For the

success of a wastewater reclamation project to materialize, it should be implemented during the ruling of an honest political party.

- Future research should comparatively assess long-term impacts on the success of wastewater reclamation projects during the ruling of different political parties and develop strategic frameworks to deal with this barrier. Cheaper drinking water sources can increase their willingness to purchase and consume. No change in tariff can shift public emotions to other factors such as disgust, leading to lower acceptance of reclaimed water. In addition, to focus on cost recovery, the pricing strategy for a reclaimed water scheme should be based on a system-wide approach involving all beneficiaries who benefit from including reclaimed water in the water portfolio. On the tariff side, cross-subsidization can be implemented in which the price of reclaimed water is recovered from tariffs imposed on freshwater supply to accommodate the cost of water reuse and motivation for the public to accept low-priced reclaimed water.
- Religion cannot be ignored as an influencing factor in accepting reclaimed wastewater for direct contact applications. Proper guidance from religious scriptures can avoid this factor. The questions and concerns from the sensitive religious communities should be addressed at the planning stage of the reclamation project rather than after implementation. This contextualization of marketing message to the communities rather than one message for all. The literature about public acceptance of reclaimed wastewater in major global religious sectors such as Christians, Hindus, and Buddhists is not available, which indicates that future research directions should be to evaluate and comparatively assess the perceptions of these communities.
- The role of media is essential to disseminate the information and the timely knowledge about the importance of wastewater reuse in efficient water management and its potential to provide reliable, safe water during a drought.
- Branding the reclaimed wastewater is one of the strategies which depend upon identifying desirable and undesirable attributes of water in public perception. A research requirement is to identify which attributes users want to be visible in the reclaimed wastewater, which will help formulate the direction of marketing campaigns for the reclaimed water.
- Building a sense of shared identity between the community and the water authority will help create the credibility and competency of water authorities. It can be developed by creating a sense of "we-ness" between the people and water authority to increase the acceptability of wastewater reuse (Ross *et al.,* 2014).

5.6 FUTURE IMPLICATIONS

5.6.1 Government

From the analysis, it was clear that trust, knowledge, and attitude play an important role in accepting wastewater reuse. Therefore, government and local water authorities can help promote the intention to accept these programs among the public through awareness programs and training programs for service providers. Government can also impose discounts or rebates to motivate the public towards the acceptability of recycled wastewater. Proper marketing strategies and social media use can help create mass awareness. The government, along with decision-makers and strategists, can help identify the underlying factors to predict the intention of the public towards the acceptability of wastewater reuse. This study will help recognize what is more significant to people's decisions to accept wastewater reuse.

5.6.2 General Public

The public will only accept the recycled wastewater when they find it suitable and beneficial. Before implementing, people should be well informed about the risks and benefits of wastewater reuse and involving them in the decisions helps to promote the acceptability. This study found that knowledge and education play an important role in the acceptability of wastewater reuse. Also, from the various religious views explained and discussed, religious leaders can influence the people at large as a community is very sensitive to religious views.

5.7 LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

The sampling was done based on ethnicity, which might have affected the results. A sampling-based on residence or living standards might have portrayed different responses.

A survey from the public elicited the limited responses, whereas potential users of wastewater reuse or experts or multi-informants might have brought more insights to the study.

The data collection method through a self-administered questionnaire sometimes poses many difficulties in understanding or limited knowledge about the problems faced. Other techniques like interviews or observation can help in eliciting more information.

This study excluded the mediating effect on the Dependent variable, behavior towards wastewater reuse. The intervening factors might exist. Examining the effects of such factors would be a new research avenue.

The study is novel concerning the new factor added like "Past Experience", but it can also be extended by incorporating other factors like Emotions or advantages of reuse (Adewumi *et al.,* 2014). This will help in gaining a better perception of wastewater reuse.

To better understand perception, emotions (Ross *et al.,* 2014) and social norms (Schweers Cook, 2005) can be essential antecedents of behavior and can be studied in future research.

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APPENDICES

Appendix 1 – Letter of Information

LETTER OF INFORMATION

Title of the Research Study: Public perceptions for the acceptability of recycled wastewater usage in households.

Principal Investigator/s/researcher: Dr Ivan Govender, DPA, MBA, B.com, LLB, CFP, BSc

Co-Investigator/s/supervisor/s: Prof Faizal Bux Name, PhD

Brief Introduction and Purpose of the Study:

The probable solutions for water stress in South Africa can be many, such as the construction of new dams and water reuse. The city of Durban faced threats of drought in 2015/16/17. This drought has highlighted increasing demand, which requires new and innovative solutions to the water supply problem. Wastewater reuse in households can be one of them. However, public acceptance of recycled water is an issue due to the various risks, especially health risks. Acceptance or rejection of wastewater reuse depends upon the various factors, which, if pronounced in a positive strategy, can result is wide acceptance of reclaimed water. The public usually favours reclamation initiatives but is hesitant to consume or ingest them. With the technical feasibility of reuse projects, the public acceptance of the recycled water in Durban is among the priority requirements, without which the project implementation will be led to financial losses. To avoid such losses and for the success of water reclamation projects, this study aims to evaluate the public perception of acceptance of reclaimed water and identify the approaches to increase its public acceptance.

Outline of the Procedures:

The study will be based on primary and secondary data. Primary data will be collected from the public using structured questionnaires. Secondary data is collected from books, journals, newspapers, magazines, online sources and project reports. The collected data will be coded and analysed through SPSS software.

Durban will be selected as a sample because people from the majority of other suburbs reside here for their living. The total sample size for all racial groups of Durban is 384.

Also, questionnaires will be distributed among local religious councils to evaluate if they have any objection to using reclaimed water. The main aim will be to

understand their religious philosophy towards wastewater reuse and their tendency to motivate or demotivate their followers to accept reclaimed water.

Risks or Discomforts to the Participant:

There will be no risks or discomforts to any of the participants

Benefits:

This work will produce two research papers for publications in accredited journals and one paper at the conference.

Reason/s why the Participant May Be Withdrawn from the Study:

There will be no adverse consequences for the participant to withdraw, and the study will not obtain data from vulnerable groups such as minors

Remuneration:

No remuneration will be paid to participants.

Costs of the Study:

There will be no costs to participants.

Confidentiality:

Specific information related to the participant's details will not be revealed.

Research-related Injury:

There will be no research-related injury in this study.

Persons to Contact in the Event of Any Problems or Queries:

Dr Ivan Govender, Senior Lecturer

Department of Entrepreneurial Studies and Management Durban University of Technology PO Box 1334, Durban, 4000

Please contact the researcher (+27 847603301.), my supervisor at +27 (31) 373 5694 or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

General:

Potential participants must be assured that participation is voluntary, and the approximate number of participants to be included should be disclosed. A copy of the information letter should be issued to participants. The information letter

and consent form must be translated and provided in the research population's primary spoken language, e.g., isiZulu.

Appendix 2 Consent

CONSENT

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Ms Samiya Gul, about the nature, conduct, benefits, and risks of this study - Research Ethics Clearance Number:

I have also received, read, and understood the above-written information (Participant Letter of Information) regarding the study.

I know that the study's results, including personal details regarding my sex, age, date of birth, initials and diagnosis, will be anonymously processed into a study report.

Given the research requirements, I agree that the data collected during this study can be processed in a computerised system by the researcher.

At any stage, without prejudice, I may withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during this research related to my participation will be made available to me.

Full Name of Participant	**Date**	**Time**	**Signature / Right Thumbprint**

I,_____(name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_____ _____ _____

Full Name of Researcher **Date** **Signature**

Full Name of Witness (If applicable)	**Date**	**Signature**

Full Name of Legal Guardian (If applicable)	**Date**	**Signature**

Please note the following:

Research details must be provided in a clear, simple and culturally appropriate manner, and prospective participants should be helped to arrive at an informed decision by use of appropriate language (grade 10 level - use Flesch Reading Ease Scores on Microsoft Word), selecting a non-threatening environment for interaction and the availability of peer counselling (Department of Health, 2004)

Suppose the potential participant is unable to read/illiterate. In that case, a right thumbprint is required, and an impartial witness, who is literate and knows the participant, e.g., parent, sibling, friend, pastor, etc., should verify in writing, duly signed, that informed verbal consent was obtained (Department of Health, 2004).

If anyone makes a mistake completing this document, e.g., wrong date or spelling mistake, a new document must be completed. The incomplete original document must be kept in the participant file and not thrown away; copies thereof must be issued to the participant.

References:

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Appendix 1 Ethical clearance letter

MANAGEMENT SCIENCES: FACULTY RESEARCH ETHICS COMMITTEE (FREC)

8 May 2020

Student Name: **Ms S. Gul**
Student No: 21959372

Dear Ms S. Gul

DOCTOR OF PHILOSOPHY IN MANAGEMENT SCIENCES: BUSINESS ADMINISTRATION

TITLE: Public perceptions for the acceptability of recycled wastewater usage in households.

Please be advised that the FREC Committee has reviewed your proposal and the following decision was made: **Approved – Ethics Level 2**

Date of FRC Approval: 8th May 2020

Approval has been granted for a period of two years from the above FRC date, after which you are required to apply for safety monitoring and annual recertification. Please use the form located at the Faculty. This form must be submitted to the FREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the FREC according to the FREC SOP's.
Please note that ANY amendments in the approved proposal require the approval of the FREC as outlined in the FREC SOP's.

Yours sincerely

_____
Prof JP Govender
Chairperson: Faculty Research Ethics Committee

Appendix 2 Permission

Directorate for Research and Postgraduate Support
Durban University of Technology
Tromso Annexe, Steve Biko Campus
P.O. Box 1334, Durban 4000
Tel.: 031-3732576/7
Fax: 031-3732946

24th November 2020
Ms Samiya Gul
c/o Department of Entrepreneurial Studies and Management
Faculty of Management Sciences
Durban University of Technology

Dear Ms Gul

PERMISSION TO CONDUCT RESEARCH AT THE DUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research and Innovation Committee (IRIC) has granted **Full Permission** for you to conduct your research "Public perceptions for the acceptability of recycled wastewater usage in households" at the Durban University of Technology.

The DUT may impose any other condition it deems appropriate in the circumstances having regard to nature and extent of access to and use of information requested.

We would be grateful if a summary of your key research findings would be submitted to the IRIC on completion of your studies.

Kindest regards.
Yours sincerely

_____
DR LINDA ZIKHONA LINGANISO
DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT DIRECTORATE

Appendix 3 QUESTIONNAIRE I (GENERAL PUBLIC)

Introduction

The purpose of the survey is to elicit your opinion on perception towards use of wastewater for residential uses. Recycled water pertains to reuse of treated stormwater, greywater and/or wastewater. **But, in this survey recycled water pertains specifically to the treated wastewater**. The survey should take (on average) between 15 and 20 minutes to complete.

Please place a tick mark in the relevant box.

Demographic Profile

1. Gender:

Male ☐ Female ☐

2. Age (Years):

<25 ☐ 25–35 ☐ 36–45 ☐ 46–55 ☐ >55 ☐

3. Education:

A. Never been to school	
B. Primary school	
C. High school	
D. Bachelor degree	
E. Post Graduate degree.	

4. Occupation:

A. Unemployed	
B. Private company	
C. Self-employed	
D. Government	
E. Others	

5. Religion:

A. Christianity	
B. Islam	
C. Hinduism	
D. Traditional African Religion	
E. Others	

6. Race:

A. Black / African	
B. Coloured	
C. White	
D. Indian / Asian	
E. Others	

7. Monthly income: (Rands)

A. <R5000	
B. R5000–R10000	
C. R10000–R15000	
D. >R15000	
E. Don't want to disclose	

8. How long you have been living in South Africa?

A. 0-5 year	
B. 5-10 years	
C. Above 10 years	
D. Since birth	

9. How many family members are living in your house?

A. 01	
B. 02	
C. >02-05	
D. >05	

10. Your source of daily drinking water

A. Tap	
B. Bottled water	
C. Bore hole	
D. Streets/ Rivers	

11. In your knowledge, which one of the below is recycled water?

A. Water taken from streams / rivers and then purified to make it fit for potable uses.	
B. Wastewater from wastewater treatment works and then purified to make it fit for potable uses.	
C. Stored rainwater and then purified to make it fit for potable uses.	
D. All of the above	

FOCUS: -TRUST

Please tick the relevant box which describes the statement.

The ratings are as follows:

SCALE				
Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

Statement	**1**	**2**	**3**	**4**	**5**
I have confidence that the local municipality will deliver satisfactory services					
I think that the local municipality has good intentions in managing Durban's water supply.					
I can depend on the water authority to provide a good quality water supply.					
I have complete trust in the water authority to provide me with good quality water supply.					
The local municipality is competent enough to manage our water supply.					
The local municipality provides the Durban community with the necessary information they want to know about their water supply.					
The local municipality does not listen to concerns raised by people like me.					
The local municipality acts in the public interest when it comes to water quality.					

FOCUS: -RISK

Statement	**1**	**2**	**3**	**4**	**5**
There would be possible problems or risks associated with the recycling scheme.					
Drinking recycled water will pose a health risk to me.					
There is a lack of qualification, experience and skilled operators in our municipality which can result in poor operation of the recycle technology causing a health risk.					
Due to corruption in our country, a cheaper technology will be adopted in the recycle water project that will be not be efficient to deliver safe drinking water.					
Customer complaints by local municipality are not addressed well. I feel, poor water quality concerns, aesthetic concerns and/or price concerns about recycled water will not be addressed.					
Local municipality lacks real time interactions with public and critical updates are delivered lately. So there is always a perception					

of health risk, in case there is any accident at recycled water treatment works.						

FOCUS: - ALTERNATIVE USAGE OF RECYCLED WATER

SCALE					
Strongly Disagree	Disagree	neither Agree nor Disagree	Agree	Strongly Agree	Don't know
1	2	3	4	5	6

Statement	**1**	**2**	**3**	**4**	**5**	**6**
I would be willing to use recycled water for watering gardens.						
I would be willing to use recycled water for flushing toilets.						
I would be willing to use recycled water for washing dishes						
I would be willing to use recycled water for washing clothes.						
I would be willing to buy a home that uses recycled water for watering gardens and flushing toilets.						
I would be willing to consume food irrigated with recycled water.						
I would be willing to swim in water containing some recycled water.						

FOCUS: - BEHAVIOURAL INTENTION

SCALE					
Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6

Statement	**1**	**2**	**3**	**4**	**5**	**6**
I support adding purified recycled water to our water supply in the dam.						
I do not want purified recycled water to be mixed with my drinking water.						
I would drink the water that was provided by this recycling scheme.						
I would protest against purified recycled water being added to my drinking water.						

Given the choice, I would not drink water that contained purified recycled water.						
I would complain to the government if purified recycled water was added to our drinking water in the dam/ reservoirs.						
I believe that this recycling scheme will be safe to use.						
My religion does allow for the use of recycled water.						

FOCUS: - KNOWLEDGE:

INSTRUCTIONS: - Please tick one of the following.

1. What is the main source of drinking water which is coming in your taps?

A. Boreholes	
B. Rivers and streams	
C. Seawater desalination	
D. Dam	
E.Treated water from reservoirs	

2. Which sector is the biggest user of water in Durban?

A. Domestic	
B. Industry	
C. Agricultural	
D. No idea	

3. Does Durban have sufficient water?

A. Severe shortage	
B.Sufficient water supply	
C. No idea	

4. A drinking water treatment plant has a source of water. This water is treated in the treatment plant and supplied in our houses through water distribution pipes. In your knowledge, which of the following is / are sources of water to a drinking water treatment plant?

A. Rivers	
B. Groundwater	
C. Industrial effluents	
D. No idea	

5. Below are some treatment processes in a drinking water treatment plant? Please tick those which you are aware about?

A. Coagulation/Flocculation	
B. Disinfection	
C. Chlorination	
D. Sand filtration	

6. At which level should people be educated about drinking water treatment and conservation?

A. Kindergarten	
B. School level	
C. College/University	
D. Professional work	
E. Home	

7. Please rate the following according to the quantity of water consumption per month in your household. (1= Highest consumption; 5 = low consumption)

A. Gardening	
B. Washing clothes and utensils	
C. Swimming pools	
D. Bathing	
E. Drinking	
F. Cleaning	
G. Cooking	

FOCUS: - FUTURE MARKETING STRATEGY

1. If your municipality would like to deliver recycled water to residents. Would you like a subsidized water bill to sign up for this water network?

   Yes ☐ No ☐

2. However, if it is not possible for municipality to provide subsidized water bill. Among the following which will motivate you to sign up for the recycled water.

A. Paying the same water bill but discount on your income tax.	
B. Rewards on shopping in local super market.	
C. Cash back on purchases with your bank cards.	
D. Discount on other municipality services	

3. If options in question 1 and 2 are not available and your municipality has to deliver recycled water to residents due to water shortages. What will you do?
   A. Sign up the recycled water blindly. ☐

B. Sign up for the recycled water demanding transparency and good customer care in the system. ☐
C. Will sign up but I will purchase bottled water also for drinking. ☐
D. Will completely reject to sign up and protest. ☐

4. How would you like to be informed about recycled water if local municipality starts supplying it? Please give your preferences on a scale from 1 – 7. (1=Most preferable; 7 = Least preferable)
   A. Social media (Facebook, Whatsapp, Instagram, Twitter etc). ☐
   B. A separate mobile app from municipality. ☐
   C. SMS ☐
   D. Email ☐
   E. Television. ☐
   F. Radio ☐
   G. Print (Newsletters, magazines etc). ☐

5. In question 4 among social media, which social network is more preferable? Please give your preferences on a scale from 1 – 5. (1=Most preferable; 5 = Least preferable)
   A. Facebook ☐
   B. Whatsapp ☐
   C. Instagram ☐
   D. Twitter ☐
   E. Snapchat ☐

Appendix 4 QUESTIONNAIRE II (Religious Organisations)

1. Name of organization

2. Religious Denomination

3. Position

4. How many years' experiences do you have in this sector?

A. 0 - 2 years	
B. 2-5 years	
C. 5-10 years	
D. >10 years	

5. Would your organization support use of recycled water in following?

Uses	Yes	No
A. Washing		
B. Bathing		
C. Gardening		
D. Other outdoor use		
E. Drinking		

6. Please consider the following statement: *Residential recycled water schemes are important to meet growing water demand and stress on existing water sources due to climate change.* **How strongly do you believe your organisation agrees with this statement?**

A. Strongly disagree	
B. Disagree	
C. Neither agree nor disagree	
D. Agree	
E. Strongly agree	

7. Is there any special criteria in your religion to use recycled water for potable needs? Please mention below.

_____
_____

_____
_____

_____
_____

_____
_____

8. If r*esidential recycled water schemes are installed in your city to meet growing water demand.* **Will your organisation help municipality to deliver a message among your followers to increase acceptance of recycled?**

A. Yes	
B. No	
C. Yes, but after charging a cost to municipality	

9. *By placing recycled water in public gatherings free of cost will help to increase confidence about recycled water.* **Will your organization be willing to allow municipality to do this in your gatherings?**

A. Yes	
B. No	

10. In which other ways, your organization would help municipality to increase public acceptance of recycled water.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Appendix 5 RESPONSES FROM THE RELIGIOUS ORGANISATIONS

1. JAMIATUL ULAMA DURBAN KZN

Questionnaire

Introduction

The purpose of the survey is to elicit **your opinion on perception towards use of wastewater for residential uses**.

1. Name of organisation? Jamiatul Ulama KZN

2. Religious interest? Islam

3. How many years' old is your organization?

A. 0 - 2 years	
B. 2-5 years	
C. 5-10 years	
D. >10 years	X

4. Based on the religious scripts, would your organization support use of recycled wastewater in following?

Uses	Yes	No
A. Washing		X
B. Bathing		X
C. Gardening	X	
D. Other outdoor use	X	
E. Drinking		X

5. Please consider the following statement: *Residential recycled water schemes are important to meet growing water demand and stress on existing water sources due to climate change.* **How strongly do you believe your organisation agrees with this statement?**

A. Strongly disagree	
B. Disagree	X
C. Neither agree nor disagree	
D. Agree	
E. Strongly agree	

6. Is there any special criteria in your religion to use recycled wastewater for potable needs? Please mention below, briefly.

Methods for rendering wastewater acceptable for potable use do exist.
Refer to: http://www.askimam.org/public/question_detail/28706
However, we remain averse to its use due to the natural repugnance of it, the possibility of sickness from endocine disrupting compounds (EDC's) and the availability of other options like desalination.

7. If r*esidential recycled water schemes are installed in your city to meet growing water demand.* **Will your organisation help to deliver a message among your followers / contributors to increase acceptance of recycled water?**

A. Yes	
B. No	X
C. Yes, but after charging a cost to municipality	

8. *By placing recycled water in public gatherings free of cost will help to increase confidence about recycled water.* **Will your organization be willing to do this in your gatherings?**

A. Yes	
B. No	X

9. If you are not willing to help in activities mentioned in question 7 and 8, what are your suggestions so that your organization help to increase public acceptance of recycled water in the community that you belong with.

We do not support the recycling of waste water for potable use. The first step required is proper conservation of existing water. We daily observe burst pipes and water wastage which government takes a very lackadaisical attitude towards. It is well known that government is keen to take on major projects through which it is easy to line pockets. If we are serious about saving water, then we should direct efforts towards conservation. Inexpensive methods also exist for harvesting water from moisture in the air and can be used to assist with water needs even in rural area.

2. ST MARY'S CHURCH GREYVILLE DURBAN KZN

Questionnaire

Introduction

The purpose of the survey is to elicit **your opinion on perception towards use of recycled wastewater for residential uses.**

1. Name of organisation?

   ST. MARY'S CHURCH, GREYVILLE.

2. Religious interest?

   ANGLICAN Organisation.

3. How many years' old is your organization?

A. 0 - 2 years	
B. 2-5 years	
C. 5-10 years	
D. >10 years	+-110

4. Based on the religious scripts, would your organization support use of recycled wastewater in following?

Uses	Yes	No
A. Washing		X
B. Bathing		X
C. Gardening	X	
D. Other outdoor use	✓	X
E. Drinking		X

5. Please consider the following statement: *Residential recycled water schemes are important to meet growing water demand and stress on existing water sources due to climate change.* **How strongly do you believe your organisation agrees with this statement?**

A. Strongly disagree	X
B. Disagree	
C. Neither agree nor disagree	
D. Agree	
E. Strongly agree	

6. Is there any special criteria in your religion to use recycled wastewater for potable needs? Please mention below, briefly.

   NO.

7. If r*esidential recycled water schemes are installed in your city to meet growing water demand.* **Will your organisation help to deliver a message among your followers / contributors to increase acceptance of recycled water?**

A. Yes	
B. No	X
C. Yes, but after charging a cost to municipality	

8. *By placing recycled water in public gatherings free of cost will help to increase confidence about recycled water.* **Will your organization be willing to do this in your gatherings?**

A. Yes	
B. No	X

9. If you are not willing to help in activities mentioned in question 7 and 8, what are your suggestions so that your organization help to increase public acceptance of recycled water in the community that you belong with.

N/A

3. SOUTH AFRICAN HINDU MAHASABHA DURBAN KZN

Questionnaire

Introduction

The purpose of the survey is to elicit **your opinion on perception towards use of wastewater for residential uses**.

1. Name of organisation?

South African Hindu Maha Sabha

2. Religious interest?

Preserving the rights, interests, culture, and religion of the Hindu community in South Africa.

3. How many years' old is your organization?

A. 0 - 2 years	
B. 2-5 years	
C. 5-10 years	
D. >10 years	X

4. Based on the religious scripts, would your organization support use of recycled wastewater in following?

Uses	Yes	No
A. Washing	X	
B. Bathing	X	
C. Gardening	X	
D. Other outdoor use	X	
E. Drinking	X	

5. Please consider the following statement: *Residential recycled water schemes are important to meet growing water demand and stress on existing water sources due to climate change.* **How strongly do you believe your organisation agrees with this statement?**

A. Strongly disagree	
B. Disagree	
C. Neither agree nor disagree	
D. Agree	
E. Strongly agree	X

6. Is there any special criteria in your religion to use recycled wastewater for potable needs? Please mention below, briefly.
The word 'Hindu' is derived from 'Sindhu' – the Sanskrit word for what is known today as the Indus River. As such, the term Hindu is directly linked to water. The Ganges river (believed to begin from the top of Lord Shiva's Head) is viewed as the most sacred river as water is believed to have cleansing abilities for the soul, mind, and body. Many reports have shown industrial contamination and pollution of the Ganges – despite this, the sacredness and importance of the Ganges remains unchanged. This is evident with the famous and world renowned Varanasi

temple, situated on the banks of the Ganges, being flocked with devotees on a yearly basis. Water and environmentalism is an important and integral part of Hinduism, with many texts and practices emphasising the importance of harmony with the natural environment. As mankind is seen as one with nature – not above or below but rather as equals. As such, if water is deemed potable by the relevant scientists, no specific criteria restricts members of the Hindu community from making use of recycled water. Socio-cultural concerns may arise however on the side of Hindu dogma, preserving, nurturing, and ensuring sustainable usage of water remains a top priority.

7. If r*esidential recycled water schemes are installed in your city to meet growing water demand.* **Will your organisation help to deliver a message among your followers / contributors to increase acceptance of recycled water?**

A. Yes	
B. No	X
C. Yes, but after charging a cost to municipality	

8. *By placing recycled water in public gatherings free of cost will help to increase confidence about recycled water.* **Will your organization be willing to do this in your gatherings?**

A. Yes	
B. No	X

9. If you are not willing to help in activities mentioned in question 7 and 8, what are your suggestions so that your organization help to increase public acceptance of recycled water in the community that you belong with.

To increase public acceptance of recycled water in the Hindu community, our organization refers to our scriptures that emphasize the importance of sustainable water usage. The following Hindu texts assist in emphasising the importance of water:

- RigVeda Samhita vii-70-4: 'Plants and waters are treasures for generations.'
- RigVeda Samhita vi-50-7: 'Waters as friends of man give full protection to his progenies.'
- Vajasaneyi Samhita iv-2: 'Waters bear off all defilements and cleanse people.'
- Taittiriya Samhita vii-4-19: 'Waters are healing and they strengthen one to see great joy.'
- Taittiriya Samhita vii-4-13: 'Offerings are dedicated to waters of wells, pools, clefts, holes, lakes, morasses, ponds, tanks, marshes, rains, rime, streams, rivers, and oceans.'
- AtharvaVeda Samhita x-5-24: 'Waters are to be freed from defilements.'

With hundreds of different texts, the importance of water is mentioned in almost every text. The abovementioned verses were specifically chosen as they represent some of the foundational Hindu texts. Reflecting on the verses, the importance of water (and water preservation) is evidently an important aspect of the Hindu faith. AtharvaVeda Samhita x-5-24 is of particular interest as it allures to water purification/recycling. From the Hindu perspective, water is a necessity for life, cleansing rituals, and future generations. Considering these texts, awareness campaigns on water scarcity, pollution, preservation, and recycling will be warmly welcomed by the Hindu community. Additionally, rainwater harvesting systems and wastewater treatment systems are methods that some temples have implemented to ensure sustainable water usage.

As a result of existing efforts made my temples, along with Hindu texts, efforts to promote water recycling in communities simply requires awareness campaigns on water scarcity and the need for the broader community to unite behind water recycling.