REVISITING THE PERFORMANCE OF MUNICIPALITIES: NEW DATA, NEW INSIGHT AND NEW APPROACHES

by

JOHANE DIKGANG, JUGAL MAHABIR AND GENIUS MURWIRAPACHENA

NELSON MANDELA METROPOLITAN UNIVERSITY IN COLLABORATION WITH THE UNIVERSITY OF JOHANNESBURG

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Private Bag X03

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orders@wrc.org.za or download from www.wrc.org.za

EXECUTIVE SUMMARY

The rationale for benchmarking in the private sector is clear and inevitable, given the competitive nature of the market. Given the lack of competition in the public sector, it is not immediately obvious that benchmarking is necessary. However, it is important that the public sector also uses benchmarking, as a means of responding to increasing pressure on the public sector to be more accountable, the need to cut costs, the need to provide more with the same or fewer resources and, the general public's demand for enhanced access and quality of public services.

One of the most important ways we can advance scientific understanding of the performance of municipalities (in their role as water service authorities) is to continually revisit previous research with new data and new approaches. Here the goal is to understand how to better measure the performance of water service authorities (WSAs). There are good reasons to be interested in measuring the performance of WSAs.

Much has been achieved in the monitoring of municipal water service performance through Blue Drop, Green Drop and No Drop ratings. Nonetheless, despite the already achieved successes of voluntary benchmarking within the South African water sector, it remains a continuous challenge to practicably support work on the original rationale of benchmarking – performance improvement.

To provide water services, WSAs incur several costs from the purchase of bulk water, water treatment, distribution of water and other activities. Since water qualifies as both a social good and social commodity, there is a great need for efficiency in its provision. Any form of technical inefficiency makes it hard for WSAs to recover the costs of providing water services.

In this study, we assessed the suitability of two new approaches, namely Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA), as tools for evaluating the efficiency of WSAs. Although the efficiency of the water sector has been variously studied utilising either DEA or SFA in other parts of the world, this is the first such attempt in South Africa. Most importantly, little is known about DEA and SFA's comparative performance. This study applied these two leading and sophisticated techniques for efficiency measurement to a new dataset for the South African water sector and compared the efficiency as estimated by the two techniques.

The DEA method yielded lower efficiency scores than the SFA method. However, the SFA scores generated in this report generally correlate with those obtained using DEA, which increases confidence in the estimates that were made in the efficiency analysis of WSAs. The efficiency scores should not be interpreted as the absolute efficiency of the WSAs, but rather as a **relative efficiency**. Although the two methods are complementary in nature, SFA is deemed to be the better methodology. It is preferred over DEA for its ability to account for data noise, such as data errors and omitted variables. Moreover, this approach allows for standard statistical tests to be used to test hypotheses on model specification, and on the significance of the variables included in the model. Furthermore, SFA is more amenable to modelling the effects of other variables (e.g. differences in population size, environment, quality, and the type of WSA – whether it is a metropolitan or a district or a local municipality).

In conclusion, the results indicate that the relative performance of SFA vis-à-vis DEA relies on the choice of functional forms. If the employed form is close to the given underlying measure, SFA outperforms DEA on a number of metrics. However, if the misspecification of the functional form was to become more serious and the degree of correlatedness of inefficiency with regressors was to increase, DEA's appeal would become more compelling.

One of the main shortcomings of the results rests with the fact that for any capital-intensive sector such as the water sector, the use of these frontier approaches, particularly in a non-dynamic, single-period, cross-sectional dimension, is not wholly appropriate to capture multi-period optimisation. Further improvement to the current analysis requires dynamic application of these frontier techniques, which requires utilisation of panel data approaches.

Performance measures used as an assessment tool were broadened to include a choice experiment model to assess how well South African water service packages satisfy household demand. There are relatively few studies that have used choice experiment models to evaluate the service performance of water utilities and customer preferences for attributes of water service packages. This study identified household preferences and willingness to pay (WTP) for service level changes by South African WSAs.

The status of water service delivery to households is not well understood and neither has it been adequately assessed. Water utility performance can be measured by gauging consumers' perceptions of how best their water service package is meeting their demands. A well-run WSA should supply all its customers at a level that meets their needs, and which they are willing and able to pay for.

The best way to develop consumer-oriented water policies is through assessing whether the water service packages provided to consumers meet their current expectations. Establishing consumer preferences and comparing them to the water service packages available is important in policy formulation. Across the world there is a growing need to assess consumer preferences for water services.

To elicit households' preferences for water service packages, the eThekwini metropolitan municipality was used as a case study in a choice experiment. A choice experiment is a stated preference survey that gives respondents a series of alternatives, differing in attributes and levels. This study used the Bayesian D-efficient design to create the hypothetical choice-sets. Six choice-sets with two alternatives were designed and presented to households. The study sample was stratified into two strata, one for suburban households and the other for township households. A total of 1002 respondents (502 from suburbs and 500 from townships) were interviewed.

The multinomial logit (MNL) model was used to estimate the value placed by households on each attribute presented in the choice experiment. In this study, consumer choices are estimated as a function of five water service attributes (cost, pipe, reliability, pressure and quality). Estimation results reveal that while the monthly cost of water services is not important to suburban households, township households are against increases in monthly water costs. This study also found that households in both strata are against any changes in the way they access piped water services. This suggests that households in the municipality are satisfied with the way they access potable water services.

The results also show that households in both strata would prefer changes in the reliability of water supply. It was found that suburban households would not prefer any changes in the pressure of the water they receive, whereas township households would. Neither suburban nor township households would prefer any changes in the current water quality, signifying their satisfaction with the quality of the water they were receiving at the time.

An analysis of households' preferences for attribute levels was conducted separately, and results show that high water pressure and water that is safe to drink are the only levels important to suburban households. In the townships, households prefer accessing piped water services at least in the yard of the household, rather than from a community tap located more than 200 metres away from their place of residence. Additionally, township households prefer water that is safe to drink, and are against unreliable water supply.

The households' marginal willingness to pay (MWTP) for water service attributes was also estimated, and the results show that estimates for suburban households are higher than those for township households. Another important finding was that suburban households are willing to pay more for water quality and pressure, while township households are willing to pay for reliability of supply and pressure. Even though township households do not prefer increases in monthly water costs, MWTP estimates show that they are willing to pay for reliability and pressure. Finally, the revelation that both suburban and township households would not prefer any changes in current water quality suggests that municipalities are satisfying demand as far as this attribute is concerned, and should maintain the current standard of providing good quality water to residents.

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ABBREVIATIONS

AIC	Akaike Information Criterion
ASC	Alternative Specific Constant
BIC	Bayesian information criterion
CE	Choice Experiments
CLM	Conditional Logit Model
CoGTA	Cooperative Governance and Traditional Affairs
CRS	Constant Returns to Scale
CVM	Contingent Valuation Method
DEA	Data Envelopment Analysis
DMU	Decision-Making Unit
DWA	Department of Water Affairs
DWAF	Department of Water and Forestry
EUWI-FWG	European Union Water Initiative – Finance Working Group
FBW	Free Basic Water
FDH	Free Disposable Hull
GDM	Gravity-Driven Membrane
GDP	Gross Domestic Product
IBT	Increasing Block Tariff
KPI	Key Performance Indicator
KZN	KwaZulu-Natal
LCM	Latent Class Model
LL	Log likelihood function
MFMA	Municipal Financial Management Act
MLM	Mixed Logit Model
MNL	Multinomial Logit
MRS	Marginal Rate of Substitution
MSA	Municipal Systems Act
MWTP	Marginal Willingness to Pay
OLS	Ordinary Least Squares

PPF	Production Possibility Frontier
PPPs	Public Private Partnerships
RUM	Random Utility Model
SALGA	South African Local Government Association
SFA	Stochastic Frontier Analysis
VRS	Variable Returns to Scale
WRC	Water Research Commission
WSA	Water Services Authority
WSP	Water Services Provider
WTP	Willingness to Pay

SECTION 1 INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1. Introduction

Water distribution is increasingly coming under scrutiny by regulators, policymakers, the business community and the research community. While benchmarking approaches have been practised in the United Kingdom (UK) for decades, in this decade we observe an increasing trend of benchmarking water utilities around the world. The natural monopoly character of water distribution, the need for fair and economically efficient prices and generally large number of observations have favoured the diffusion of efficiency analysis.

Benchmarking of water distribution utilities is now practised around the world, even in the less-regulated African and Asian water sectors. A distinction can be made between single-country studies for developed countries and South America, and cross-country analyses for less-developed countries such as Africa, Asia and Central America. This pattern is mainly a function of data availability and data sources. In countries where reliable data is available, cross-country studies are more rare, to avoid the empirical problems of comparing different operating environments (von Hirschhausen et al., 2009).

There is much that has been achieved in the monitoring of municipal service performance through Blue Drop, Green Drop and No Drop ratings in South Africa. An on-going WRC project (Project no. K5/2118) demonstrates that relative efficiency can also readily be monitored and cost efficiency indices estimated by applying efficiency analysis (Hosking, 2014). Nonetheless, despite the already achieved successes of voluntary benchmarking within the water sector it remains a continuous challenge to support practicably the work on the original rationale of benchmarking – performance improvement. The challenges, as identified in previous WRC-initiated stakeholder forums, include the following:

- Gaps in existing data sets that limit the sample size and thereby also the scope for identifying real efficient municipalities
- Lack of verification of accuracy of data
- Alternative theories on the reason for relative efficiency rating/ranking.

The water sector in South African is characterised by both achievements and challenges. There is a general consensus that the government has made some progress in increasing the number of people with access to water. However, it is not clear if such success was achieved through efficiency. This is particularly critical in a country like South Africa where there are wide ranges of competing demands for scarce resources.

1.2. Background

In South Africa, a municipality accorded the right to provide water services is called a Water Services Authority (WSA). Only municipalities can be WSAs and, of the 278 South African municipalities, only 152 are WSAs (DWA, 2013). In some cases, a WSA may contract a Water Services Provider (WSP) to provide water services on its behalf. The DWA (2014) describes a WSP as a WSA or any person who has a contract with a WSA to provide retail water services to consumers within a specific geographic area. Some WSAs appoint water boards (state-owned regional providers of bulk water) to act as WSPs and offer retail water services to final consumers (DWA, 2014).

WSAs have a mandate to provide water at affordable tariffs. However, evidence reveals that some of them can barely cover their operational costs through their revenue, due to low tariffs and other reasons. Corruption, slackness and ineptitude have been evident in South African municipalities, with some even failing to efficiently provide basic services (Westhuizen and Dollery, 2009). To provide water services, WSAs incur costs from the purchase of bulk water, water treatment, distribution of water and other activities. Since water qualifies as both a social good and social commodity, there is a great need for efficiency in its provision. Any form of technical inefficiency makes it hard for WSAs to recover the costs of providing water services.

For regulatory purposes, it is now customary practice in several countries to benchmark the performance of utilities. The best known examples are Switzerland, the UK, the

USA, Germany, the Netherlands and Italy (Baranzini, Faust and Maradan, 2010). Several indicators have been proposed to evaluate the performance of water utilities. Relevant information derived through performance benchmarking is needed in order to regulate water utilities. The more complete the information is, the more likely it is that the right problems are identified and appropriately addressed. Performance benchmarking techniques have become strategic tools for water regulators (De Witte and Marques, 2012).

Benchmarking utilities promotes competition between utilities, promotes information sharing and transparency, helps to identify performance trends, and provides consumers with information on the utilities (Gallego-Ayala, Dimene, Munhequete and Amos, 2014). Techniques for benchmarking are based on either parametric methods that develop cost and production functions (such as stochastic cost functions) or non-parametric methods that are based on data envelopment analysis (Baranzini et al., 2010).

In recent years, a wide range of alternative approaches have been proposed with which to measure technical efficiency (see Gong, 1992). However, we know little of their comparative performance. In this study, we use two approaches, Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) to estimate technical efficiency in South African WSAs. Most importantly, this report examines the relative strengths of the two different methodologies – SFA and DEA – in estimating WSA-specific technical efficiency.The varied nature of water provision in South Africa where consumers in different municipalities receive water services from different WSAs makes it ideal to examine the performance of WSAs. South African municipalities are diverse, ranging from metropolitan to district and local municipalities. The performance of municipalities regarding water provision is assessed. Equally, water revenues for several WSAs have been failing to cover water provision costs. Therefore, it is imperative to examine if the budget deficits are not a result of technical inefficiency and ineptness.

1.3. Aims of the Study

The primary aim of this study was to construct a new data set, and generate results based on this new data set using new approaches. The study proceeded as follows, tracing and capturing information for 88 South African municipalities. This complements and expands on the initial WRC efforts, which yielded a data set of around 47 municipalities. Therefore, this study aimed to increase the number of municipalities for which there was adequate data to about 88. The rationale for this was to enable a more encompassing and expanded model by which to determine efficiency frontiers.

Thus, this report constitutes the first step of applying the new assessment tools more broadly by filling in as many of the data gaps and addressing as many errors as was feasible. In sourcing the data, we engaged with the Benchmarking Initiative team, the South African Department of Water and Sanitation (DWS), the South African Local Government Association (SALGA,) National Treasury and Statistics South Africa.

It is well documented in the literature that the most important benchmarking approaches used in the regulation of water services by water providers are the econometric-based models such as the SFA and linear programming techniques such as DEA. The introduction of new, more rigorous and robust quantitative benchmarking analysis enables participants to quantify providers' progress towards meeting policy objectives, helps specialists to identify high-performance utilities (whose processes may be adopted by others) and allows regulators to develop targets and incentives for providers (see Mugisha et al., 2007). The legislative framework under which municipalities operate may directly or indirectly affect their performance.

This study aimed to introduce new and more sophisticated performance benchmarking methods in the context of South African municipalities providing water services by using both the SFA and DEA methods to estimate technical efficiency scores. These scores essentially quantify the efficiency with which WSAs are using their given resources and consequently rank their service delivery performance in this regard. Such an assessment will likely be one of the first applied to South African municipal WSPs and will give us insight into the appropriateness of such approaches.

1.4. Study Objectives

There are two components to a performance benchmarking assessment: one is to assess relative efficiency and the other is to assess short-term customer satisfaction. Hence, the objectives of this study were:

1) To trace and capture information for South African municipalities, encompassing and expanding models to be estimated by which to calculate efficiency frontiers, and to undertake an audit of the information captured. This will result in a new data set.

2) To calculate a broader and more credible set of technical and allocation efficiency indices, using the most appropriate of the two new methods for estimating efficiency performance benchmarks (SFA or DEA). The results will give us new insights into the adequacy of these new methods.

3) To undertake selective municipal performance asessments to how well South African water service packages provided are satisfying demand, and from these generate demand performance indices.

1.5. Report Structure

This report consists of three sections dealing with heterogeneous issues, based on the type of problem or questions asked, as well as the methodologies used to approach them. The overriding fundamental principle was to add two components to the performance benchmarking assessment, and how our understanding of this can provide the necessary information for policymakers.

This first section establishes the nature of the study, provides a background to the study and study information, introduces the research issues and outlines the objectives of the report.

Section 2 presents alternative tools to measure water provision efficiency. This section comprises four chapters (chapters 2–5).

Section 3 (chapters 6–7) investigates municipal performance, in terms of how water service packages satisfy demand, using choice experiments.

1.6. Conclusion

Although water policy is formulated at national government level, the provision of potable water is a constitutional mandate of South Africa's two-tier local government sphere (Republic of South Africa, 1996). This two-tier local government system comprises 257 municipalities divided into metropolitan (category A), local (category B) and district (category C) municipalities. A municipality accorded the right to provide water services is called a Water Services Authority (WSA) and not all municipalities are WSAs. WSAs are determined by the Minister of Cooperative Governance and Traditional Affairs (CoGTA), with currently 152, i.e. 8 metros, 123 local and 21 district municipalities, being authorised to provide water. While most WSAs provide water directly to final consumers, others use third party providers in the form of other municipalities, water boards (state-owned regional providers of bulk water) or private companies, among others (DWA, 2014).

The importance of water provision for human sustenance and development needs to be balanced with its sustainability, given the scarcity of this precious resource. Therefore, it is imperative that municipalities are largely efficient and effective when delivering water services to communities. To provide water services, municipalities use several inputs, including materials in the form of bulk water, labour and capital in the form of infrastructure. Municipalities need to be efficient in the use of these resources to meet community demand for water. However, recent studies have shown local government in South Africa to be highly inefficient in its delivery of services (Westerhuizen and Dollery, 2009; Mahabir, 2014). Specifically in the delivery of water, such inefficiencies are characterised by financially unviable water departments, high water losses and water interruptions.

The research efforts yielded a cross-sectional data set for 88 municipalities based on the 2013/14 financial year. This study then audited the data. The next step was to calculate a broader and more credible set of technical efficiency measures using both the SFA and DEA. The SFA analysis should assess whether technical inefficiencies exist among South African WSPs. DEA on the other hand, should measure the relative performance of the municipalities in our sample. The monitoring and evaluation of municipalities is key in curbing the evident inefficiencies in the delivery of water in the country and improving the performance of local government in general.

In South Africa, the use of such methods to quantify inefficiencies and benchmark performance of municipal water providers is largely untested. Current initiatives by the DWS (formerly the DWA), such as the Blue Drop and Green Drop programmes, play an important role in supporting the regulatory process by measuring the performance of drinking water and waste water management respectively. However, the performance scores and audits that emanate from these programmes are either single-dimensional measures or composite indices that do not explicitly quantify inefficiency in water service delivery. Performance benchmarking using efficiency estimation methods provides a holistic indicator of service delivery performance by encompassing the entire operational and production process in the efficiency assessment.

SECTION 2

ALTERNATIVE TOOLS TO MEASURE WATER PROVISION EFFICIENCY

CHAPTER 2: INTRODUCTION

2.1. Background

According to Joskow (2007), natural monopolies (a common occurrence in the water sector) can lead to rampant price excesses, inefficiencies, and poor quality, because of a lack of direct competition. Reynaud (2013) argues that it is for this reason that natural monopolies tend to be subject to regulation. Although Ofwat (2013a) and Coco and De Vincenti (2008) highlight the many concerns about regulation, they argue that despite these concerns, regulation applied appropriately can reduce inefficiencies, control costs, and improve environmental factors.

Water regulation is of growing importance – especially in water-scarce developing countries, such as South Africa – in light of the negative impact that global warming is having on water supplies. We expect this negative impact to correlate positively with the costs and efficiency of water provision. In other words, the more the negative impact, the higher both costs and efficiency will be. For regulation to be effective, it is vital to assess the performance of WSPs. Water utilities around the world are under immense pressure to perform. The rationale behind benchmarking is illustrated by Figure 1 below:

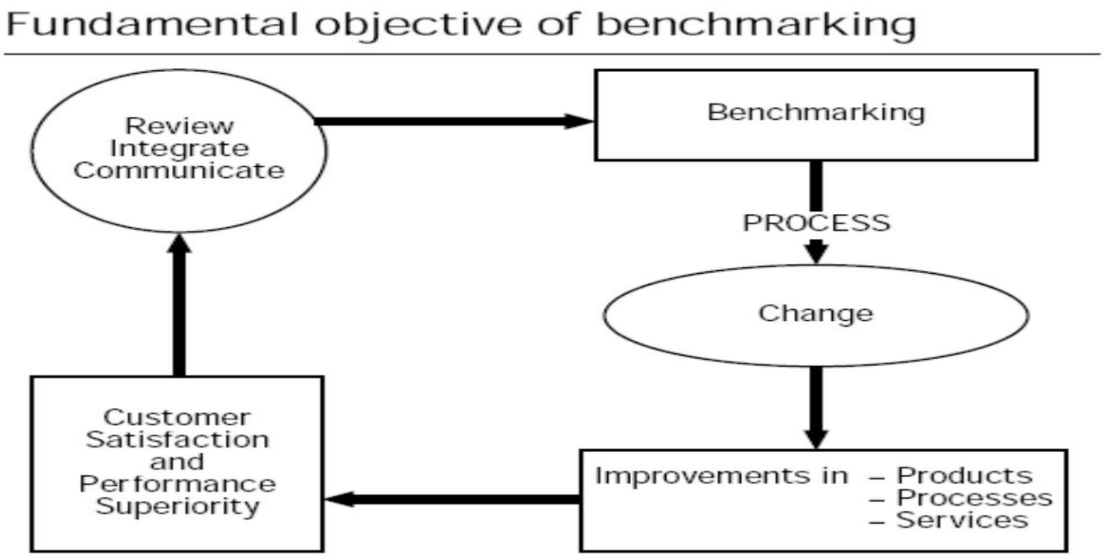


Figure 1: Underlying aim of benchmarking (Source: Booth, 1995)

Figure 1 above reflects the cyclical and continuous nature of benchmarking. The starting point is at ‘Benchmarking’, and the process also ends there, at which point a benchmarking cycle has been completed. Benchmarking challenges are taken on in one or more cycles. In reality, this cyclical process will continue indefinitely, with new challenges as a result of many factors, including product or process innovation.

Benchmarking enables both regulators and utility managers to make performance comparisons over time, across water utilities and across countries. It can act as a conflict resolution tool between the two groups, by allowing interested stakeholders to focus primarily on performance. Moreover, it can aid in bridging the gap between technical researchers and those practitioners currently involved in assessing government agencies and water utilities (Berg, 2007). In a number of countries, the performance information generated through benchmarking initiatives is used by regulators to oversee water provision services.

Benchmarking originated in the 1970s in the manufacturing industry, as an important instrument for staying ahead of the competition (Blokland, 2010). In the 1980s, Xerox officially introduced it as a concept for identifying the best sectors and for implementing the best practices used by them to enhance performance (Mehta, Mehta and Immanuel, 2013). Figure 2 diagrammatically depicts superior performance in an industry.

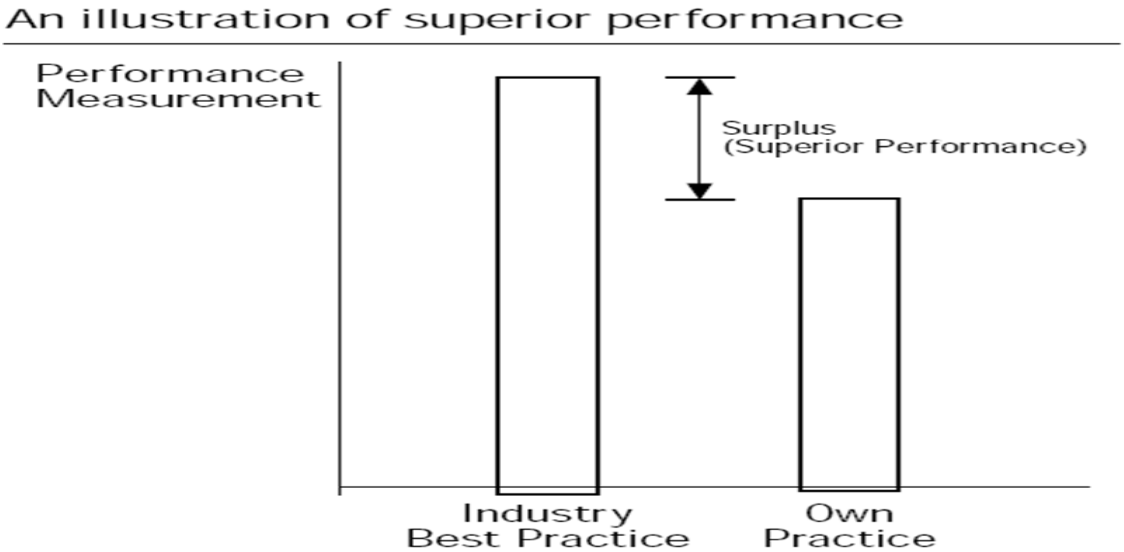


Figure 2: Illustration of best performance in the sector (Source: Fong, 1998)

After the initial performance assessment, one or more performance indicators will show how much the value for the other organisation is greater than for yours. However, you may find that you outperform others in terms of other indicators. There is always something to learn from others, and something for others to learn from you.

Overall performance in the water sector can be rated in terms of four areas of management: customer satisfaction, water resources, financial management and human resources management (Water and Sanitation Programme report, 2009). According to Blokland (2010), after some time the public sector followed the example of the private sector in also adopting benchmarking. It is increasingly used by regulators, national and local governments, and public enterprises, as a way to improve both transparency and the performance of public services. The first application of benchmarking in the water and sanitation sector dates back to 1980. Since then, there has been increasing use of benchmarking by water utilities. The process is shown in Figure 3 below:

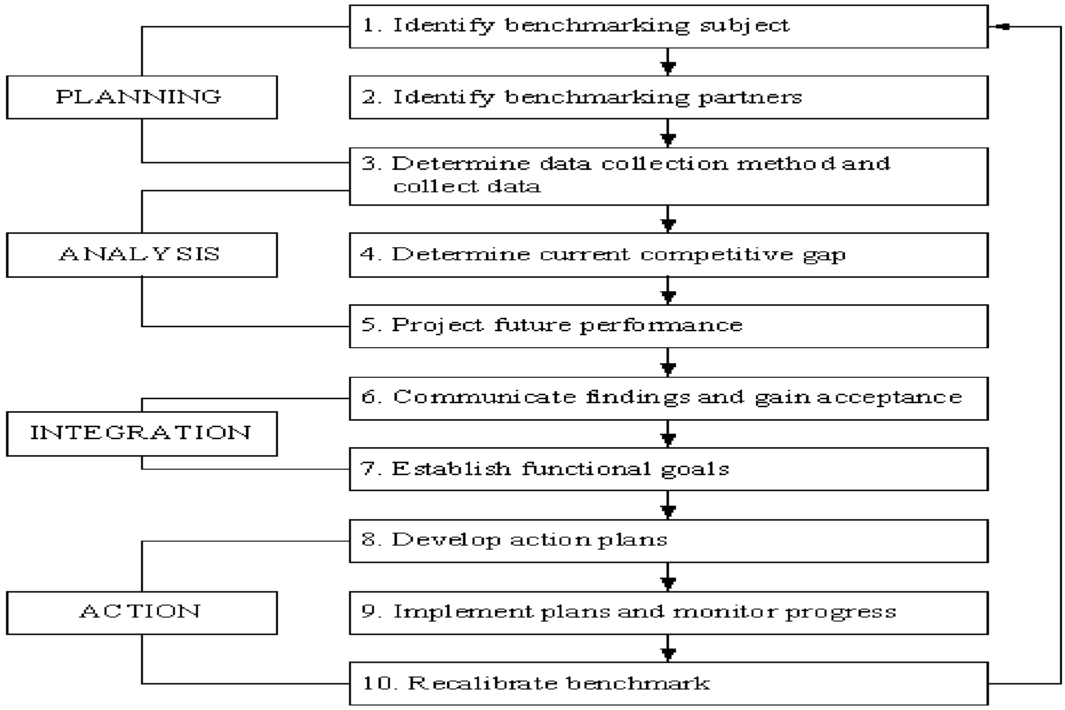


Figure 3: Benchmarking process (Source: Camp, 1989)

The benchmarking process has four distinct stages; planning, then data analysis, followed by integration and action. Most importantly, it is a systematic process with distinct phases, and a continuous process. It does not end; after completion of step 10, another round starts with step 1.

The initial efforts in benchmarking in the water sector were in Europe and North America (Mehta et al., 2013). Benchmarking in the water sector is mostly voluntary. It entails assessing performance in the water sector within the same water utility, either over time or between similar units. Alternatively, performance can be assessed against that of other water utilities, nationally or internationally. However, regulators make limited use of benchmarking, especially in developing countries.

Quantitative benchmarking tools may be necessary (though they may not be sufficient) for promoting policies that can enhance municipal (and) sector performance. The introduction of more rigorous and robust analysis enables participants to quantify a utility's progress towards meeting policy objectives, helps specialists to identify high-performance utilities (whose processes may then be adopted by others), and allows regulators to develop targets and incentives for utilities (Mugisha et al., 2007).

A sector-wide benchmarking approach has been adopted by water utilities who have used two formats: metric benchmarking, which focuses mainly on quantitative comparison of key performance indicators (KPIs), either between water utilities or over time within the same utility; and process benchmarking, which focuses on learning from best performers, and concentrates on the underlying utility processes with the goal of enhancing performance. A large body of experience is available on the application of metric benchmarking in both developed and developing countries. Metric benchmarking is essentially the comparative reporting of performance indicators (Mehta and Mehta, 2010).

2.2. Benchmarking Efforts in South Africa

In the water sector, the need for standardised information, transparency and accountability has intensified in recent years. In response, benchmarking has gained momentum. The primary goal of undertaking benchmarking exercises is to provide KPIs for measuring performance. KPIs enables water utilities to compare their performance with that of other utilities and to identify areas that must improve.

Benchmarking of water and sanitation services poses serious challenges, particularly in developing countries. This is because the conventional benchmarking approach used in developed countries is not applicable in cases where water supply is intermittent, accessed by non-piped means, unmetered, and has a significant number of poorer customers on shared public connections (Mehta et al., 2013).

Although water and sanitation provision is widespread in South African urban areas, there is a lack of data regarding the quality and level of service. Very little is known about how South African municipalities compare in their capacity as WSAs. One of the major challenges for measuring and eventually benchmarking the performance of WSAs is a lack of standardised data, gaps in existing data, and lack of data verification.

The initial efforts at performance benchmarking in South Africa, which were initiated by the SALGA around 2001, failed. Around 2006, government made further efforts. Since then, much has been achieved in the monitoring of municipal service performance through the Blue Drop and Green Drop ratings. These initiatives employ many indicators to measure service delivery and environmental services. The annual process entails collecting and auditing data, and publishing the performance indicators. To date, performance assessment efforts in South Africa have focused mainly on performance comparisons between municipalities, using set guidelines and standards, such as for water quality. In this report, performance assessment focuses on performance measurement (i.e. financial and cost efficiency).

Section 2 of this report serves two purposes. First it aims to trace and capture information about South African municipalities, to enable a more encompassing and expanded model to be estimated by which to calculate efficiency frontiers, and to undertake an audit of the captured information. Second, it aims to capture a broader and more credible set of technical and allocation efficiency indices, using the most appropriate techniques for efficiency performance benchmarking.

By providing comparative information on utilities' costs and performance, this report can be used by various stakeholders in the water sector. These stakeholders include the municipalities themselves, in identifying their performance relative to peers, government (to monitor and amend sector policies and programmes), regulators (to ensure that adequate incentives are provided for improved municipal performance, and that consumers obtain value services), consumers and general users, international agencies and advisers (to perform an evaluation of utilities for borrowing purposes), and private investors, for identifying investment opportunities.

Performance monitoring data can help increase transparency in the water services sector, and satisfy the public's demands, the regulators, and government. Moreover, it can help to enhance the image of the sector as a whole. A review of the literature suggests that municipalities that participate in benchmarking initiatives acknowledge these advantages, and are willing to continue the recurring-cycle process in order to continue improving.

The legislative framework under which municipalities operate may affect their performance, either directly or indirectly. For this reason, the next section briefly discusses the South African legislative framework for the water sector.

2.3. Legislative and Other Mandates

In terms of legislative compliance, section 74 of the Municipal Systems Act (MSA, Act 32 of 2000)and section 62 (1) (f) of the Municipal Financial Management Act (MFMA, Act 56 of 2003) require municipalities to adopt and implement a tariff policy. In crafting a tariff policy, each municipality should take into consideration the specific legislation applicable to every service. The policies are applicable to all tariffs for water, solid waste and electricity. Section 74 (2) of the Systems Act sets out principles that must be reflected in this policy. For example, the City of Cape Town policy (City of Cape Town, 2012) stipulates that, where appropriate and possible, the amount users are charged for services will generally be in proportion to their use of that service, as calculated on a consumption-based tariff basis. It further states that this is dependent on the service being able to provide discernible, universal and regular metering and readings.

Access to water services is enshrined as a basic human right in the South African Constitution (Republic of South Africa, 1996). This right to water for South Africa's citizens was further emphasised with the introduction of the Free Basic Water (FBW) Policy of 2002, which entitles each poor South African to at least 25 litres of free basic potable water per day, at a minimum flow rate of not less than 10 litres per minute, and within 200 metres of a household (DWAF, 2002). The policy assumes an average household of eight members receiving 6 000 litres of free basic water per month (DWAF, 2007).

In South Africa, regulations under the Water Services Act (Act 108 of 1997) recommend an increasing block tariff (IBT) to address problems of unequal income distribution and to provide fair access to water (Bailey and Buckley, 2005). The IBT structure is such that the more water you use, the higher the rate per kilolitre you will pay. Municipalities in South Africa are recommended to use the IBT structure, but they do so using a varying number of blocks, size of blocks and rates.

In addition to the Free Basic Water Policy of 2002, municipalities in South Africa are guided by several other pieces of legislation when they determine water tariffs. These include the MFMA, Act 56 of 2003, and the Municipal Systems Act, 2000 (MSA, Act

32 of 2000). Section 17 (3) (a) (ii) of the MFMA allows municipalities to impose any municipal tax and set any tariff that may be required for the budget year. In setting their tariffs, section 22(a) (i) and (ii) of the MFMA require municipalities to make public their annual budget and invite the local community to submit views and representations. Section 11(3) (i) of the MSA stipulates that each municipality can exercise its legislative or executive authority to develop and adopt policies, plans, strategies and programmes, including setting targets for delivery.

Both the MFMA and the MSA give municipalities the executive authority to determine the structure of their water services tariffs independently. Due to this autonomy, IBT structures across municipalities differ in terms of the number of blocks created and the charges for water services in each block. For domestic water users, some municipalities have five blocks (see eThekwini Municipality, 2015a; 2015b), while others have as many as eight blocks (see Johannesburg Metropolitan, 2015).

In addition to the free basic water provided in the first block, some municipalities allocate some water for emergencies; for example, the City of Johannesburg allocates 4kl free of charge to each consumer annually for emergencies. Tariffs charged to household units where water is consumed through a break pressure tank are different from tariffs charged to household units where all or part of the water through a connection is supplied without the intervention of individual break pressure tanks. Some municipalities group households considered indigent into different categories and give them a percentage payment exemption, which is based on each household's poverty level (see Johannesburg Metropolitan, 2015). For classes of water consumers other than domestic consumers, some municipalities levy a flat rate on water consumption (an example is the City of Cape Town), while others levy a flat rate plus a fixed tariff, calculated daily, based on connection size (an example is the eThekwini Metropolitan).

In practice, an IBT can only be applied where users are connected to the water network. This applies mainly to those in urban areas. In such cases, consumption can be measured accurately. The 'spirit' of the IBT framework is that, ideally, a water bill should reflect a consumption-based tariff. This implies that a user should be billed for the water that they have consumed or used every month; but it is common in South

Africa for municipalities to base their water bills on estimates. This is in contrast to the IBT framework which recommends actual readings.

One implication of water bills based on estimates is that a municipality may underestimate consumption for extended periods of time, with the user not aware that the charges are based on estimates as opposed to actual readings. At a much later stage, the user is confronted by a large bill, with pressure from the municipality to settle it. Alternatively, estimates could be much more than the user is actually using. In this case, the opportunity cost is that the money could have been used more productively elsewhere. This is a common occurrence in South Africa. Municipalities such as Tshwane continue to base their water bills on estimates rather than actual water readings.

As yet, there is no legal recourse for consumers who find themselves in either situation, as the IBT guidelines are just recommendations, which municipalities may implement, or merely take into consideration, without necessarily implementing them. In conclusion, there are no guidelines for handling the above in current South African law. This implies that by law, a municipality may use estimated readings. Additionally, the way that municipalities function in South Africa, billing based on estimations is allowed for in municipal regulations. There is unhappiness about this, as some feel that these municipal provisions are grossly abused; as a result, there are various efforts aimed at changing municipalities' attitudes towards their obligations to consumers.

2.4. Conclusion

Access to water is a basic human right in South Africa. Municipalities have a mandate to provide water at affordable tariffs. However, most municipalities barely cover their operational costs. Dikgang and Hosking (2016) point out that the challenge for the general public is to balance the ever-growing demands for fresh water for different needs. Fresh water is required for direct human consumption, agriculture, forestry and industry.

According to Von Hirschhausen et al. (2009), water distribution is increasingly coming under scrutiny from regulators, policymakers, and the business and research communities. While there have been early applications of benchmarking approaches in the UK, in this decade we have observed increasing trends in the benchmarking of water utilities around the world. As indicated earlier, the natural monopoly character of water distribution, the need for fair and economically efficient prices and the generally large number of observations have favoured the diffusion of efficiency analyses.

Despite the successes of voluntary benchmarking already achieved in the water sector, it remains a continuous challenge to practicably support work that fulfils the original rationale of benchmarking – performance improvement.

CHAPTER 3: EFFICIENCY ANALYSIS ECONOMETRIC APPROACH

3.1. Introduction

The importance of water provision for human sustenance and development needs to be balanced with its sustainability, given the scarcity of this precious resource. Therefore, it is imperative that municipalities are efficient and effective when delivering water necservices to communities. To provide water services, municipalities would use several inputs, including materials in the form of bulk water, labour, and capital in the form of infrastructure. Municipalities must be efficient in the use of these resources in order to meet community demand for water. However, recent studies have shown local government in South Africa to be highly inefficient in their delivery of services (Westerhuizen and Dollery, 2009; Mahabir, 2014). Specifically in the delivery of water, such inefficiencies are characterised by financially unviable water departments, high water losses, and water interruptions.

The monitoring and evaluation of municipalities is key in curbing the evident inefficiencies in the delivery of water services in the country, and for improving the performance of local government in general. It is now customary practice in several countries to quantify inefficiencies and benchmark the performance of water utilities through efficiency estimation methods. Performance benchmarking techniques have progressively become strategic tools for water regulators (De Witte and Marques, 2012). Generally, benchmarking incentive schemes have a positive effect on efficiency, and subsequently result in improvements in performance (De Witte and Marques, 2010).

The efficiency estimation methods used to benchmark the performance of water providers primarily compute a production possibility frontier (PPF), against which inefficiency is quantified and performance ranked. The PPF illustrates the maximum possible outputs that can be produced with available inputs. Decision-making units (DMUs) operating below the computed PPF are inefficient in their use of their inputs, and are thus sub-performers in a given sample of DMUs. In the literature, the most common techniques used to compute a PPF are either based on parametric methods, such as SFA, or non-parametric approaches, such as DEA and free disposable hull (FDH) methods (Baranzini et al., 2010; Mahabir, 2014).

In South Africa, the use of such methods to quantify inefficiencies and benchmark the performance of municipal water service providers is largely untested. Current initiatives by the DWS such as the Blue Drop and Green Drop programmes, play an important role in supporting the regulatory process, by measuring the performance of drinking water management and wastewater management respectively. However, the performance scores and audits that emanate from these programmes are either one-dimensional measures, or composite indices that do not explicitly quantify inefficiency in water service delivery. Performance benchmarking using efficiency estimation methods provides a holistic indicator of service delivery performance, by encompassing the entire operational and production process in the efficiency assessment.

This report aims to introduce more sophisticated performance benchmarking methods in the context of South African municipalities providing water services, by using both the SFA and DEA methods to estimate technical efficiency scores. These scores will essentially quantify the efficiency with which WSAs are using their given resources, and consequently will rank their service delivery performance in this regard. Such an assessment is likely to be one of the first applied to South African municipal water service providers.

Most importantly: please exercise extreme caution in interpretation, as our emphasis is on the demonstration of the two proposed methodologies by exploring WSA datasets, and not on the results of the study. Therefore, any attempts to compare WSAs based on findings generated in this report will result in misleading conclusions.

3.2. Water Provision in South Africa

South Africa is a unitary state with three spheres of government: National Government, nine provincial governments, and local government. The Constitution of the country assigns service delivery responsibilities to each sphere, along with revenue instruments to fund the provision of such services. The three spheres are considered distinctive, interdependent and interrelated, with each sphere having some degree of autonomy in the manner in which they deliver their services. This system is supported by a strong spirit of cooperative governance – with national government playing an important role in monitoring and evaluating the performance of provinces and municipalities, while also playing a key role in capacity building and intervention when service delivery is compromised at these levels.

The delivery of potable water is a competence of local government; however, the actual authority to deliver water lies with the 152 WSAs, as determined by the Minister of CoGTA. The 152 WSAs encompass district municipalities that deliver within the jurisdiction of their local municipalities, and local municipalities that deliver within their own jurisdictions. In most cases, where a district is authorised to provide water, the local municipalities in the area do not have such authority[1]; and in instances where the locals within a district are authorised, the related district is not authorised. This asymmetric delivery of water services across South African local government is due to the incapacity of many local municipalities, particularly those in the former homeland areas[2], to deliver water services.

Although such an arrangement initially had some merit, the ultimate delivery of water services in the country can be complicated. This is apparent where WSAs have the legal option to appoint a third party to provide all or part of the water service on their behalf. Section 76 of the MSA differentiates between internal service delivery mechanisms and external delivery mechanisms. The former is the delivery of the water service by a department, administrative unit or business unit within a municipality (Peters, 2012); the latter includes the partial or complete outsourcing or commercialising of the delivery of the water service. External delivery of a service by an authorised water service provider would include outsourcing the service to another municipality, municipal entity, an organ of state or the private sector, through commercialising the delivery of the service or through public private partnerships (PPPs).

As mentioned above, the National Government has the constitutional mandate to monitor the performance of sub-national government, and to set policy norms and standards for service delivery. In terms of water provision in the country, this mandate

[1] If the local is deemed a municipality with a large enough budget, then the local is authorised as opposed to the district. This usually occurs when the local municipality is considered a ‘secondary city’.
[2] Under the pre-1994 apartheid government, these were areas that were designated for specific black ethnic groups, with a high degree of political autonomy and even so-called ‘independence’ from South Africa.

lies with the DWS. The DWS is essentially the regulator of water delivery; it sets national norms and standards for water services, monitors the performance of WSAs, provides support to WSAs, and intervenes in cases of water service delivery failure. As the regulator of water services, the ability to monitor performance is key in designing policies, providing support and intervening when WSAs fail to provide water services.

Due to these institutional arrangements, water provision in South Africa varies considerably across municipalities, making monitoring and evaluation difficult. This is further complicated by some municipalities treating their own bulk water, while the majority purchase bulk water from water boards. As an example, the City of Cape Town metropolitan municipality harvests and treats most of its bulk water, while others such as the Tshwane Metropolitan Municipality treat a portion of their own water while purchasing the reminder from water boards.

Although there are WSA municipalities that are legal custodians of water services within their jurisdiction, the methods used to deliver water services vary. Using efficiency analysis to benchmark municipal performance can deal with the inconsistences in the way water is provided across the country. Efficiency analysis methods can cater for instances where there are differences in treatment methods, or instances where both a district and a local are providing water, even though only the former is authorised. These discrepancies are accounted for in the inputs used and outputs produced, thus making efficiency analysis a more accurate benchmark than other one-dimensional or ordinal methods.

3.3. Methods Used for Benchmarking

The methods that are used for benchmarking can be categorised as follows:

1. Partial metric methods (single indicators)
2. Overall performance indicators (composite index)
3. Frontier methods (modelling overall system performance).

The most commonly applied method for assessing benchmarking outcomes is direct comparison of outcomes, combined with an appreciation of the contextual factors. This ‘partial metric method’ approach is very attractive, as the data are not manipulated in any way, and as such, are well understood by most users of the information (including water utilities and customers). The outcomes allow a ranking of utilities for each indicator studied, which provides a good entry point for enhancing performance. However, this technique does not allow for more advanced analysis of the data to answer questions pertaining to the overall efficiency of the water utility (inputs to outputs), opportunities for cost minimisation, and the overall ranking of utilities. For this type of analysis we need other methods, such as ‘overall performance indicators’ and ‘frontier’ methods (Murungi and Blokland, 2016).

Frontier methods are a common way to assess the performance of water utilities. There are two analytical approaches often used to measure productivity relative to an efficiency frontier, namely SFA (stochastic frontier analysis) and DEA (data envelopment analysis). Frontier methods establish the efficient performance ‘frontier’ for a sample of firms – in our case, WSAs. This efficiency frontier is the benchmark against which the relative performance of other WSAs is measured. Efficiency considers both inputs and outputs. An efficient WSA is one that maximises output for a given set of inputs, or minimises inputs for a given set of outputs. A possible taxonomy of efficiency measurement tools is shown in Figure 4 below (Sarafidis, 2002):

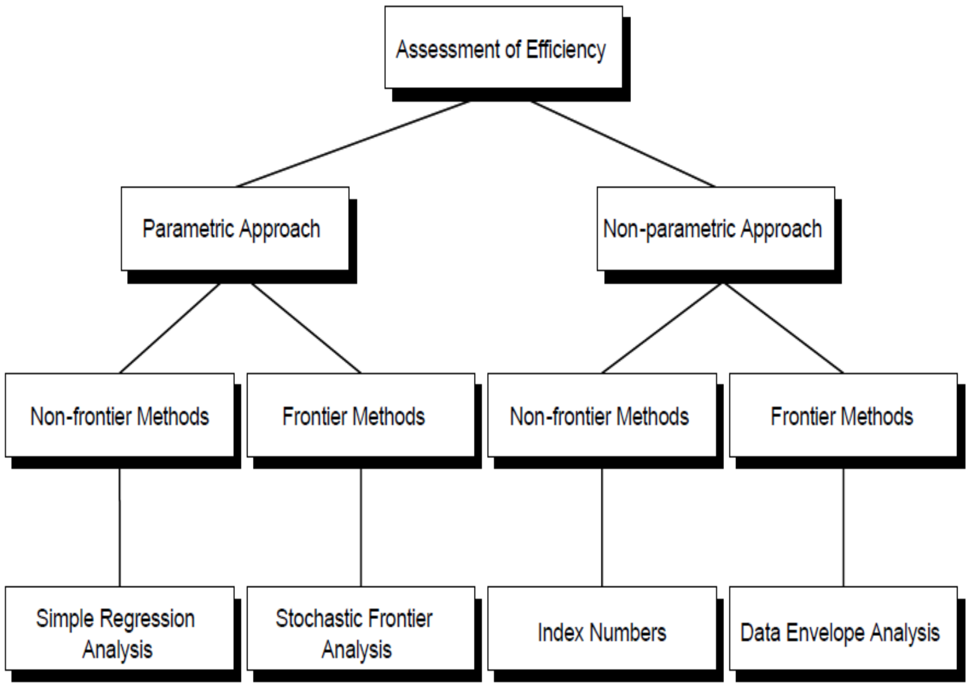


Figure 4: Taxonomy of efficient measurement instruments

3.4. Stochastic Frontier Analysis – Illustration

The frontier can best be understood as a line on which one finds (in our case) the municipalities that use the minimum inputs to produce the same quantity of outputs as the others. The further a firm is from the efficiency frontier, the less efficient it is. This is shown graphically in Figure 5 below:

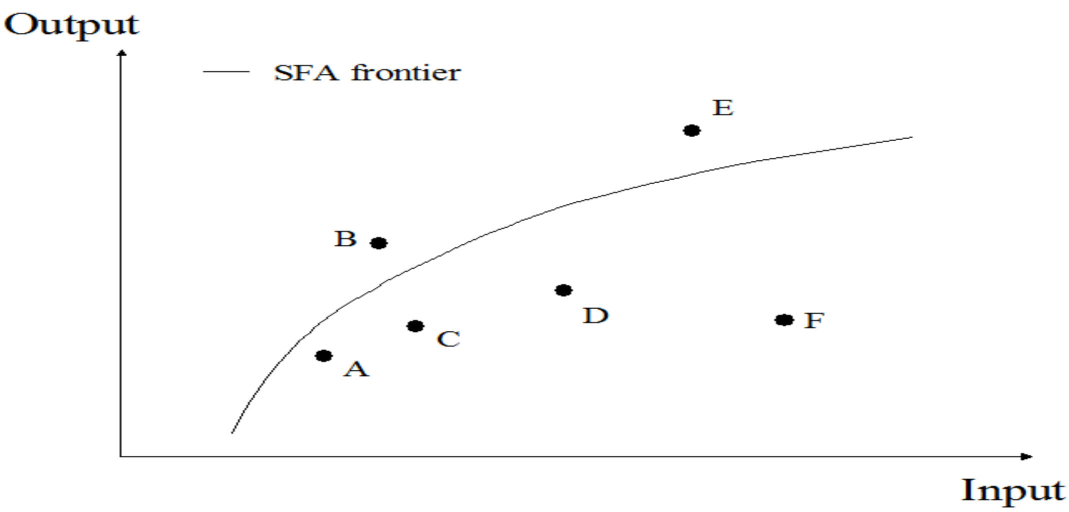


Figure 5: Stochastic Frontier Analysis

SFA assumes there is ‘noise’ in the data, as in Figure 6 below:

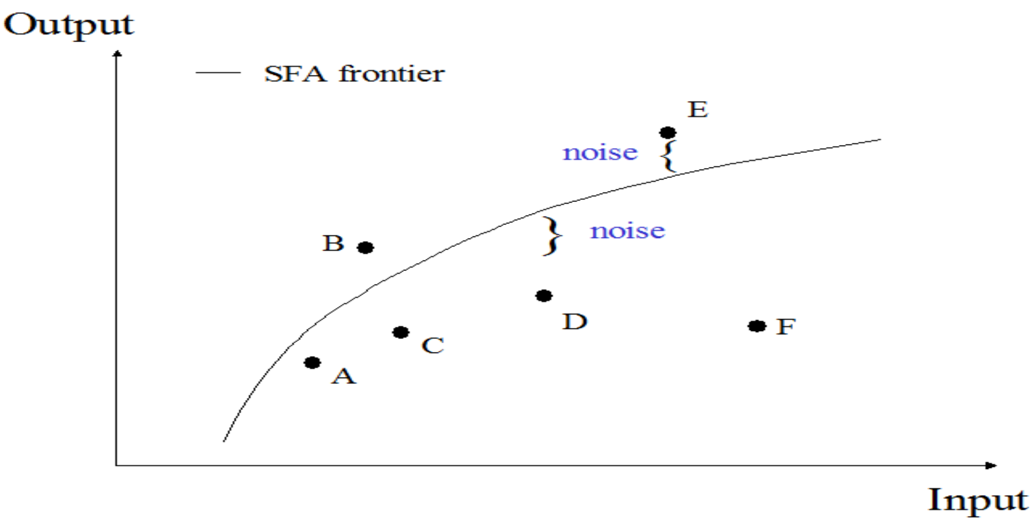


Figure 6: Stochastic Frontier Analysis, capturing noise in the data

An SFA production function permits measurement error and random variation. It attempts to create a balance, by having two error terms – one for noise, and one for inefficiency, as in Figure 7 below.

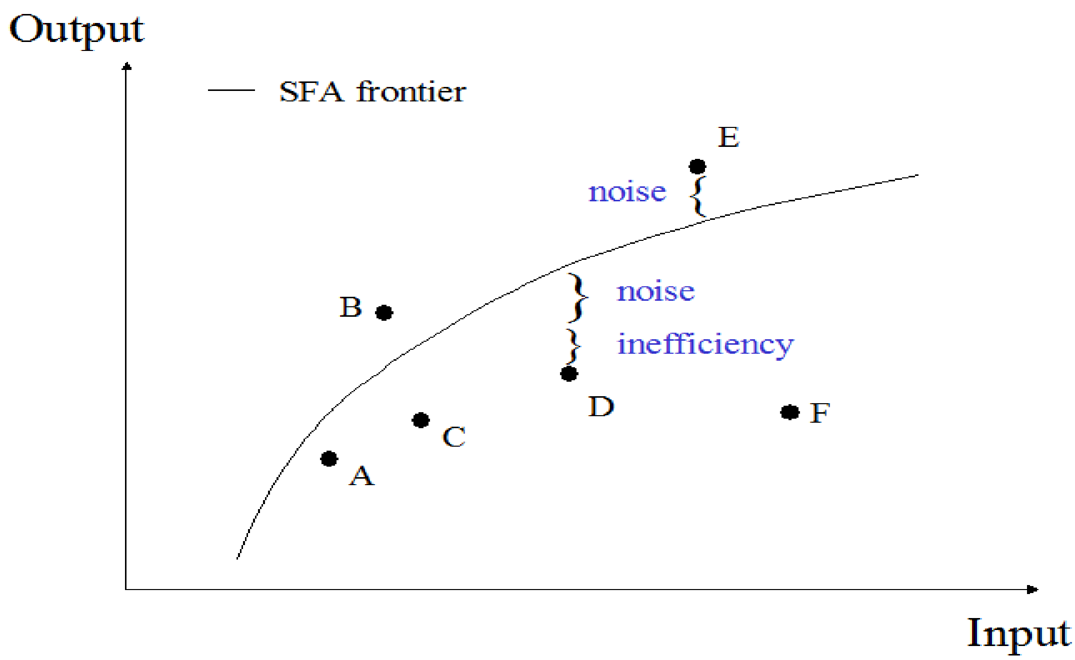


Figure 7: Stochastic Frontier Analysis – decomposition of the error term

The interest in SFA is in the residuals. The error term is decomposed into random noise and inefficiency terms.

3.5. Stochastic Frontier Analysis – Empirical Literature

The literature reveals a plethora of studies using SFA to estimate technical and cost inefficiencies in water utilities. However, most of these studies were conducted in developed countries, and only a few in developing countries. The scarcity in the literature for developing countries is mainly due to the unavailability and inaccessibility of data. This section reviews some empirical literature from developed countries, developing countries, and South Africa.

Horn and Saito (2011) used stochastic cost frontier analysis with a true fixed-effect model to estimate cost efficiency and economies of scale in 831 Japanese water utilities. A panel dataset for the period 1999 to 2008 was used. By using stochastic cost frontier analysis with a true fixed-effect model, the study separated the effects of heterogeneity of water utilities from the efficiency score. Total cost, which was the sum of labour, capital and material costs, was estimated as a function of water delivery volume, network characteristics, labour price, capital price, and other control variables such as network density and time trend. Results from the study revealed that the average cost inefficiency is rather high in Japanese water utilities.

Baranzini, Faust and Maradan (2010) employed SFA to estimate cost inefficiencies in 330 Swiss water utilities, using data for the period 2000 to 2005. The study also investigated the impact of environmental characteristics outside the control of the water utilities on costs and inefficiency measures. To estimate cost inefficiency, Baranzini et al. expressed total cost as a function of output, unit variable costs (labour price, energy price, material price and other costs), capital price and environmental factors (customer density, load factor, pumped water, types of customer, and water adduction). Results from the study showed that environmental factors affect the costs of water utilities and have an impact on estimated efficiency, but less than traditional factors do. The results further revealed that the rankings of the water distribution utilities were very similar between the models that take environmental factors into account and those that do not, but differ substantially between the variable and total cost models.

Filippini, Hrovatin and Zorić (2007) used SFA to estimate cost efficiency and economies of scale in 52 Slovenian water distribution utilities, using panel data for the period 1997 to 2003. As in the studies by Horn et al. (2011) and Baranzini et al. (2010), the model adopted by Filippini et al. expressed total cost as a function of water output, price of labour, price of material, price of capital, number of customers served, and size of service area. However, Filippini et al. added water losses, water treatment, use of surface water, use of underground water, and changes in technology as additional exogenous variables. The study revealed that significant cost inefficiencies existed in the Slovenian water utilities, and the introduction of an incentive-based price regulation scheme was recommended as a possible solution.

Souza, Faria and Moreira (2007) used SFA to assess cost efficiency in 279 Brazilian public and private water supply companies. The model parameters were estimated by maximum likelihood, using cross-sectional data for the year 2002. Unlike the work of

Filippini et al. (2007) and Baranzini et al. (2010), in which the total cost function was estimated, Souza et al. estimated the average cost function. The study expressed average cost as a function of water output, price of capital, price of labour, capital, labour, average tariff and average profit. The study revealed no evidence that private firms differ significantly from public firms in terms of efficiency.

In South Africa, Tsegai, Linz and Kloos (2009) used Zellner's iterative efficient method to estimate the structure of water supply costs and tariffs for 50 WSAs, in the years 2004 and 2006. Total variable costs were estimated as a function of water output per year, price of bulk water, price of labour, price of materials, price of capital, and other variables such as population, poverty rate, and backlog rate. The results indicated that marginal costs were higher than the actual tariffs that WSAs charged to consumers. The study recommended that charging a higher price would assist WSAs to recover part of the cost of supplying water. Even though the study did not use SFA, as the other studies reviewed in this section did, the study is considered important, as it gives a useful view of the water sector in South Africa. The other important aspect of the study is how the researchers compiled the variables used in their model.

Other studies include the work of Vishwakarma and Kulshrestha (2010), which used SFA to estimate technical efficiency in urban water utilities of 18 cities in Madhya Pradesh, India, and revealed that some of the water utilities performed better than others in terms of efficiency scores. Aubert and Reynaud (2005) also estimated the impact of regulation on cost efficiency, in France's 211 Wisconsin water utilities for the years 1998 to 2000, and found that the utilities' efficiency scores were partly explained by the regulatory framework.

3.6. Estimation Methodology: Stochastic Frontier Analysis

Developed by Aigner, Lovell and Schmidt (1977), SFA is a parametric benchmarking method that assumes either a Cobb-Douglas, log-linear or translog functional form. Being econometric in nature, the SFA method has several advantages over DEA, such as being able to account for noise by including an error variable (u) in the function (Vishwakarma and Kulshrestha, 2010). Non-parametric methods, mainly FDH, can generate efficiency scores based on the used sample. In this regard, DMUs considered efficient in one sample may be inefficient if analysed in another sample. Extreme outliers in each particular sample affect efficiency hugely when non-parametric methods are employed. Such limitations do not exist in SFA, because the method requires the specification of a functional form, and efficient DMUs are determined based on the specified functional form. The original formulation that is the foundation of SFA, as developed by Aigner et al. (1977), is:

$$y = \boldsymbol{\beta}'\mathbf{x} + v - u, \tag{1}$$

where y is the observed outcome (goal attainment), $\boldsymbol{\beta}'\mathbf{x} + v$ is the optimal frontier goal pursued by the individual (for example, maximum production output or minimum cost), $\boldsymbol{\beta}'\mathbf{x}$ is the deterministic part of the frontier and $v \sim \mathrm{N}[0, \sigma_{\mathrm{v}}^2]$ is the stochastic part. The two parts together constitute the stochastic frontier. The amount by which the observed DMU fails to reach the optimum (the frontier) is u, where:

$$u = |U| \text{ and } U \sim \mathrm{N}[0, \sigma_{\mathrm{u}}^2] \tag{2}$$

(stochastic cost frontier changes to $v + u$). In this context, u represents the inefficiency. This is the normal-half-normal model, which forms the basic form of the stochastic frontier model (Aigner et al., 1977).

Different specifications of the terms u and v distinguish the stochastic frontier models. This study provides estimators for the parameters of the normal-half-normal SFA model. The half-normal SFA model specification assumes u to be independently half-normally $[\mathrm{N} + (0, \sigma_u{}^2)]$ distributed, and the idiosyncratic component v is assumed to be independently $[\mathrm{N}(0, \sigma_v)]$ distributed over the observation. Other specification models of SFA include the normal-exponential model and the truncated-normal model. These basic models differ in their specification of the inefficiency term (u). Unlike in the normal-half-normal model where u is independently half-normally $[\mathrm{N} + (0, \sigma_u{}^2)]$ distributed, u in the normal-exponential model is independently exponentially distributed with variance ($\sigma_u{}^2$). In the truncated-normal model, u is independently $[\mathrm{N} + (\mu, \sigma_u{}^2)]$ distributed with truncation point at 0. For the sake of consistency and simplicity, this study will estimate technical inefficiency in South African WSP municipalities using the normal-half-normal SFA model.

Water provision involves several activities, such as water extraction, treatment, transfer, storage, pressurisation of pipelines, distribution to final consumers, quality monitoring; and metering (Filippini et al., 2007). All these activities involve the use of labour, capital and materials. To characterise the process of water provision and efficiency, it is essential to assume the existence of a mathematical relationship between inputs and output. South African municipalities have a legal obligation to serve all customers at a given water quality standard, thereby limiting their ability to produce output that maximises profit. Therefore, municipalities are expected to make their main decisions influenced primarily by the desire to achieve the optimal quantities of inputs.

This study estimates an SFA production function, using the total quantity of water supplied to customers as water output (Q), and three inputs, in the form of total employees in the water sector of a municipality (L), total bulk water purchases (B), and the length of the mains for each municipality (K). These inputs are aimed at covering labour, material and capital inputs respectively. Therefore, the SFA function used in this study assumes the following form:

$$lnQ_i = F(L_i, B_i, K_i) \tag{3}$$

Equation 3 can be specified as follows to determine the error term, which comprises the inefficiency component and random noise terms:

$$\ln Q_i = \alpha_i + \ln L_i + \ln B_i + \ln K_i - \mathrm{u}_i + v_i \tag{4}$$

where v_{it} is the noise term assumed to be in normal distribution $v_i \sim \mathrm{N}[0, \sigma_\mathrm{v}^2]$. The u_i notation is the non-negative inefficient term (which is the distance from the observed output to the minimum output on the frontier). This study assumes u_i to be independently half-normally $[\mathrm{N} + (0, {\sigma_u}^2)]$ distributed, and the idiosyncratic component v_i is assumed to be independently $[\mathrm{N}(0, \sigma_v)]$ distributed over the observation.

Similar to ordinary least squares (OLS), the assumptions on the error term essentially require both the efficiency term and the error term to be homoscedastic. However, WSAs in South Africa are diverse, ranging from large metros to small, rural local municipalities. Therefore, such differences are likely to be captured in the error term, resulting in heteroscedasticity. According to Kumbhakar and Lovell (2000), heteroscedasticity in the random noise term can result in biased estimates, while heteroscedasticity in the inefficiency term can lead to misleading efficiency scores. A way of remedying heteroscedasticity in an SFA function is to account for the key drivers of the variation when estimating the efficiency term. This is done by estimating a simultaneous regression on the production function, the inefficiency term and the random error term. This is specified as follows:

$$u_i = \alpha_1 + \alpha_2 \ln pop + \alpha_3 D + \delta_i \quad (5)$$

The variation in the inefficiency term u_i driven by heteroscedasticity is controlled for by regressing the u_i on the total population receiving water, as well as dummy variables indicating if the municipality is a city (metropolitan or secondary city) or a district municipality. This will ensure that the size of the municipality is accounted for and does not impact on the efficiency estimates.

3.7. Data Envelopment Analysis – Illustration

The production frontier is plotted using linear programming. Each WSA is compared to the frontier, and assigned an efficiency score. This is illustrated in Figure 8 below:

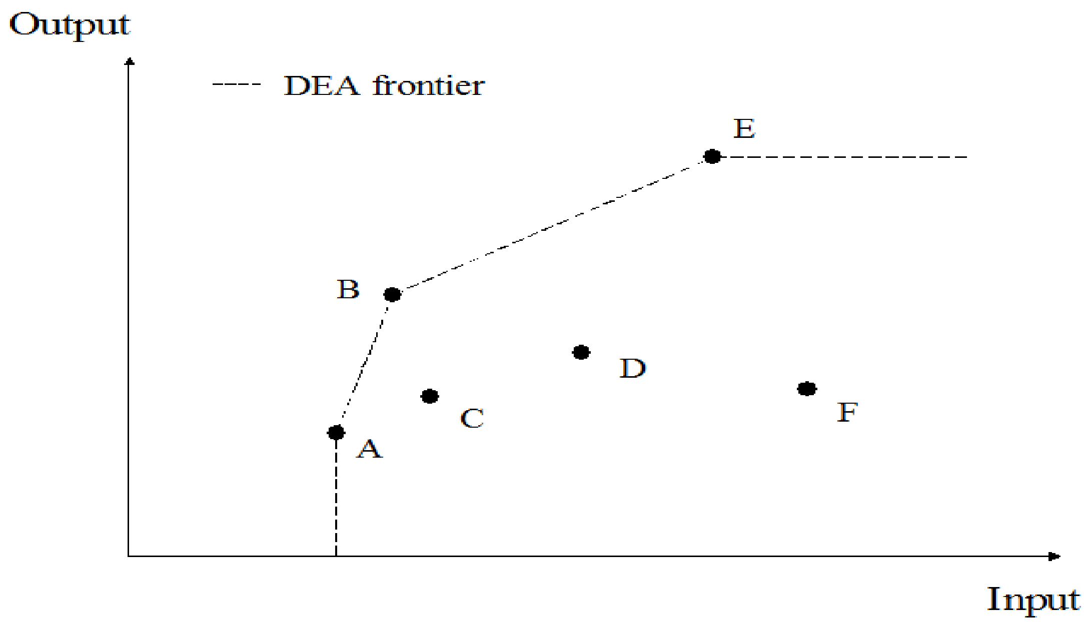


Figure 8: Data envelopment analysis

DEA measures efficiency relative to members of the sample – in our case, a sample of WSAs. It is very sensitive to outliers. Each municipality is compared to the frontier, and allocated an efficiency score. The score can be interpreted as an inefficiency score from the most efficient WSAs in the same sample. The inefficiency is illustrated in Figure 9 below:

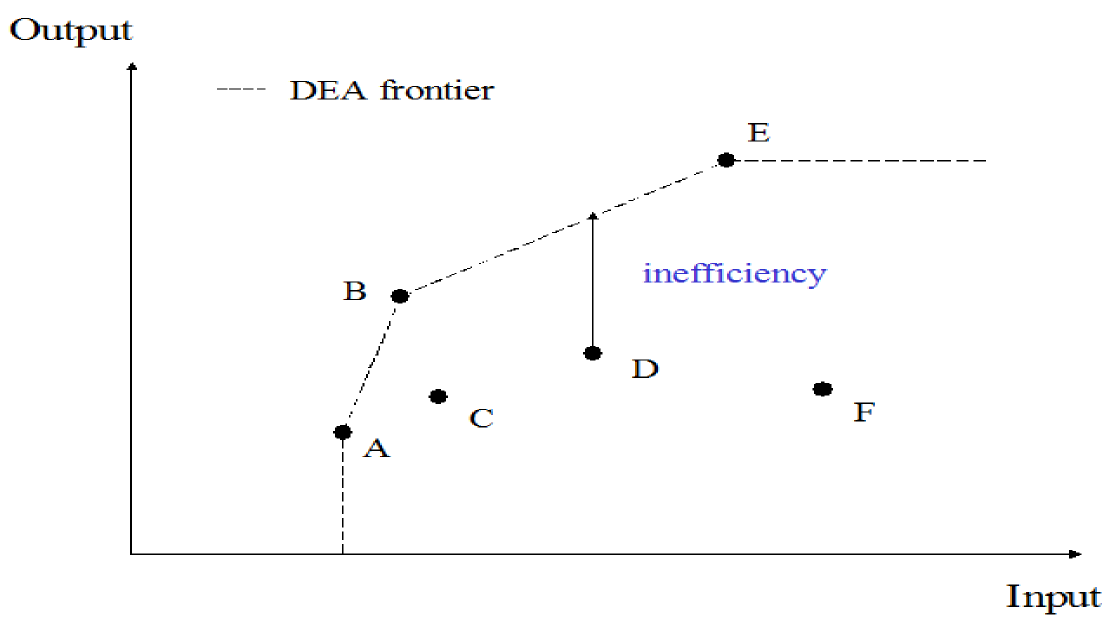


Figure 9: Inefficiency captured by data envelopment analysis

WSAs inside the frontier are less efficient. To plot Figure 9 above, data on input and output quantities of each WSA is required. A DEA can be conducted under the assumption of constant returns to scale (CRS) or variable returns to scale (VRS).

3.8. Stochastic Frontier Analysis – Empirical Literature

Across the world, several studies have used DEA to estimate the efficiency scores of water utilities. However, there is limited literature on the subject in South Africa. One study conducted in South Africa is Brettenny and Sharp (2016); in developed countries, there are many such studies. This section reviews these studies.

Brettenny and Sharp (2016) used an input-oriented DEA model to estimate the efficiency of 88 South African rural and urban WSAs. The study used data for the financial year 2009/2010. Operating costs were the sole input variable in the study. Brettenny and Sharp divided their sample into 44 urban WSAs and 44 rural WSAs. Efficiency was estimated independently for these groups. The study revealed both excellent and poor performance. The average technical efficiency for urban municipalities was 0.636, and 0.526 for rural municipalities; suggesting that on average, urban and rural municipalities respectively can spend 36.4% and 47.4% less, and still achieve the given levels of water service delivery.

Guerrini, Romano, Leardini and Martini (2015) used a two-stage DEA approach to investigate the effects of size, scope and density in the Danish wastewater industry. The study analysed datasets from 62 utilities. In Denmark, public water operators owned by municipalities serve 60% of the Danish population, while private operators in the form of consumer cooperatives and not-for-profit companies serve the remaining 40%. Results from the study revealed that Danish wastewater utilities achieved low average efficiency, and that this was significantly affected by operational and environmental variables. Guerrini et al. grouped their area of study into areas of very high density, high density, low density and very low density. The results revealed that firms operating in very high density areas were more efficient, and those that managed both water and wastewater saved costs due to vertical integration.

Carvalho, Pedro and Marques (2015) used DEA to identify the most efficient water utility groups in Brazil. This was motivated by the reality that Brazilian water utilities provide their services under a natural monopoly, with very little incentive for efficiency; affecting the customers, at the end of the line, in the form of expensive tariffs. Carvalho et al. also used the statistical test method to identify the sources of inefficiency. The study depicted four main realities. Firstly, utilities that provided both drinking water and wastewater services were found to be more efficient than those that only provided the water supply service. Secondly, utilities were more efficient before the implementation of the regulatory framework. Thirdly, local utilities were more efficient than regional utilities. Finally, utilities featuring private participation were more efficient than those with no intervention of any private entity in their management.

Cruz, Carvalho and Marques (2013) used a shared-input DEA model to measure (separately) the efficiency of water and wastewater services in Portugal. Estimating efficiency separately was motived by the complexity involved in measuring efficiency when the same operator is responsible for the delivery of more than one service. The study used data for seven years (2002 to 2008), from 45 water utilities serving a population of 4.4 million people. The study showed that the major share of the total cost of multi-utilities providing water and wastewater services is allocated to drinking water supply. The shared-input DEA revealed that there is no statistically significant difference between the efficiencies of drinking water services and wastewater services. It was further revealed that operators providing retail and wholesale drinking water and wastewater services have higher cost efficiencies for both services.

De Witte and Marques (2010) used an input-oriented DEA to compare the efficiency of the drinking water sectors in the Netherlands, England and Wales, Australia, Portugal and Belgium. The study investigated whether regulatory and benchmark incentive schemes enhance the efficiency of utilities. De Witte and Marques used the number of employees and the length of mains as inputs, with water delivered and number of connections as outputs. Results from comparing incentive schemes revealed large differences in bias and noise-corrected first-stage inefficiencies. In summary, the analysis of De Witte and Marques showed that in the absence of clear and structural incentives, the average efficiency of the utilities falls in comparison with utilities that are encouraged by incentives. To be precise, the analysis revealed that benchmark incentive schemes have a positive effect on efficiency.

Byrnes, Crase, Dollery and Villano (2009) used input-oriented DEA models to estimate the scale and technical efficiencies of wastewater utilities located in non-metropolitan areas in New South Wales and Victoria, Australia. The study used operating expenditure as the input, and the output variables were total volume of wastewater treated and number of complaints. This study showed that wastewater utilities in Victoria were 22% more efficient than similar-sized utilities in New South Wales. The study further revealed that the larger utilities governed by skills-based boards had higher technical efficiencies than those which operated within a local government.

In conclusion, the studies reviewed in this section used either SFA or DEA to estimate efficiency in various water utilities across the globe, and showed that inefficiencies do exist in water utilities. The majority of the studies reviewed estimated the total cost frontier as a function of water output, unit variable costs, and exogenous factors such as customer density, load factor and the number of customers. In South Africa, there is a large gap in the literature concerning these two approaches to benchmarking water utilities. This study will bridge the gap, by applying the two benchmarking techniques to estimate technical efficiencies in South African water services that provide water to municipalities.

3.9. Estimation Methodology: Data Envelopment Analysis

Developed by Charnes, Cooper and Rhodes (1978), DEA is a powerful non-parametric benchmarking technique used to evaluate the efficiency of production units. The DEA model proposed by Charnes et al. (1978) had an input orientation and assumed constant returns to scale (CRS). DEA compares DMUs and identifies the most efficient among those units. The best-practice utilities are relatively efficient, shown by a DEA efficiency rating of $\theta = 1$; while inefficient utilities are shown by an efficiency rating of less than 1 ($\theta <$ l). DEA provides an efficiency rating that is generally between zero and 1, interchangeably referred to as an efficiency percentage between the range of 0 and 100% (Sherman and Zhu). The upper limit of efficiency scores is set as 1, or 100%; in other words, a utility cannot be more than 100% efficient.

The main purpose of the DEA method is to construct a non-parametric envelopment frontier over given data points, such that all observed points are on or below the frontier. If there is data on K inputs and M outputs on each of N decision-making units for the i^{th} DMU, these variables are represented by the vectors x_1 and y_1 respectively. The KxN input matrix (X) and the MxN output matrix (Y) represent the data for all N decision-making units.

For each DMU, the idea is to obtain a measure of the ratio of all outputs over all inputs, such as $u'y_i/v'x_i$, where u is an Mx1 vector of output weight and v is a Kx1 vector of input weights. Optimal weights are selected by specifying the following mathematical problem:

$$
\begin{aligned}
&\max_{u,v}(u'y_i/v'x_i),\\
&\text{st} \quad u'y_j/v'x_j \leq 1, j = 1,2, \dots, N,\\
&\quad\quad u, v \geq 0
\end{aligned}
\tag{6}
$$

The process involves obtaining values for u and v, such that the efficiency measure of the i^{th} DMU is maximised – subject to the constraint that all efficiency measures are equal to or less than one. To avoid the problem inherent in this particular ratio of an infinite number of solutions, the constraint $v'x_i = 1$, is imposed. This constraint provides that:

$$
\begin{aligned}
&\max_{\mu,v}(\mu'y_i),\\
&\text{st} \quad v'x_i = 1,\\
&\quad\quad \mu'y_j - v'x_j \leq 0, j = 1,2, \dots, N,\\
&\quad\quad \mu, v \geq 0,
\end{aligned}
\tag{7}
$$

This form is called the multiplier form of the linear programming problem, where the change of notation from u and v to μ and v reflects the transformation. When the duality in linear programming is used, an equivalent envelopment form of the programming problem is derived. The equivalent envelopment form is presented as:

$$
\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
&\text{st} \quad -y_i + Y\lambda \geq 0, \\
&\quad\quad \theta x_i - X\lambda \geq 0, \\
&\quad\quad \lambda \geq 0,
\end{aligned} \tag{8}
$$

where θ is the scalar and λ is an $Nx1$ vector of constants. An envelopment form of this nature is generally preferred, as it includes lesser constraints than the multiplier form (K+M < N+1). The obtained value of θ will be the efficiency score of the i^{th} DMU. This value (the efficiency score) will satisfy $\theta \leq 1$, with a value of 1 indicating a point on the frontier; that is, a technically efficient DMU (Farrell, 1957). As soon as the linear programming problem is solved N times, once for each DMU in the sample, efficiency scores are obtained for each DMU.

Similar to the SFA estimation above, in this study, a DEA analysis of the country's WSAs will be undertaken using water quantity delivered to customers as the output variable (Q), and three input variables, in the form of total employees in the water sector of a municipality (L), total bulk water purchases (B), and the length of mains for each municipality (K). These inputs are aimed at covering labour, material and capital inputs respectively.

A major concern with DEA is that the results are very susceptible to the influence of outliers. Going further, a sample that has too much variation may result in inaccurate efficiency estimates. The sample of municipal WSAs in South Africa is quite diverse, and includes municipalities in extremely varying contexts. Although such differences can be easily accounted for in the SFA estimation of efficiency scores, a two-staged regression analysis is required to account for a similar variation in the DEA-generated scores.

As this goes beyond the scope of this paper, other methods will be used to account for differences across municipalities. Firstly, municipalities will be grouped in specific categories, to allow for comparison across similar types of municipalities. Analysis will include municipalities grouped as cities (metros and secondary cities), district municipalities and local municipalities. Secondly, in the production function, VRS will be assumed, as opposed to CRS. We assume that different WSAs are in different stages of the production process; VRS would take this into account.

3.10. Conclusion

To estimate technical efficiencies in South African WSAs, this study uses both stochastic frontier analysis (SFA) and data envelopment analysis (DEA) methods. Using SFA, municipalities will be benchmarked based on their inefficiency scores. The scores will be used to group municipalities into top performers and worst performers. The DEA will then be used to compare the top performers with the least performers. This will give an indication of the performance of these two distinct groups. Subsequently, the inefficiency scores pulled out from the SFA may be regressed against possible determinants, so as to ascertain the causes of the inefficiencies.

In estimating efficiency, both SFA and DEA assess whether DMUs are maximising output given a certain level of input, or whether DMUs minimise input to achieve a given level of output. Studies that separately estimate both the cost and technical efficiency of water utilities using either SFA or DEA, or both, are common in the literature. When estimating the cost efficiency of water utilities, the selection of variables has been consistent in the literature. The majority of the SFA studies estimating cost efficiency use the cost of providing water services (total cost or average cost) as the output, and the volume of water supplied together with input prices (price of labour, price of capital, price of materials) as inputs (see Souza et al., 2007; Filippini et al., 2007; Baranzini et al., 2010; Horn and Saito, 2011).

For both DEA and SFA based on the production function, a plethora of studies use the volume of water supplied by the utility as the output variable, with physical units of labour, capital and materials as inputs (see Brettenny and Sharp, 2016; Guerrini, et al., 2015; Carvalho et al., 2015; De Witte and Marques, 2010). It is common practice in efficiency analysis to control for heterogeneity using the population size of the catchment area (see Aubert and Reynaud, 2005; Filippini et al., 2007), the number of customers (see Guerrini et al., 2015; Cruz et al., 2013), and population density (see Horn and Saito, 2011).

Variables used to estimate technical efficiency in WSAs have all been used previously in the water efficiency literature. This study, like the studies by Guerrini et al. (2015) and Carvalho et al. (2015), uses the volume of water supplied by each municipality as the output variable in both SFA and DEA estimations. For each WSA in this study, the input variables used are the number of water services employees, bulk water purchases (used as a proxy for raw materials), the length of main water pipes (used to represent capital), and population (used as a variable to control for heterogeneity in the municipalities). Studies in the literature that have used very similar input and control variables include De Witte and Marques (2010) for number of employees; Horn and Saito (2011), for materials; Vishwakarma and Kulshrestha (2010) for length of pipe network; and Aubert and Reynaud (2005) and Filippini et al. (2007) for population.

The authorised consumption, expressed in kilolitres per annum, is used to represent water output. Authorised consumption is a good measure of output, because it shows the total volume of metered and/or non-metered water taken by all water customers implicitly or explicitly authorised by the municipality. The number of both full-time and part-time water services employees, excluding managers, is used to account for the number of employees. Estimating the number of employees is complicated by the fact that in some municipalities, positions may be shared across service departments.

The material used in the provision of water services is represented by the bulk purchases made by each municipality. Although some municipalities have their own water resources and do not buy in bulk from water boards, while others produce some of their water and buy the rest, most South African municipalities purchase bulk water from water boards. The length of mains is used to account for each municipality's capital. This is the total length in kilometres of water pipes owned by each municipality in a particular year. The population served by each municipality during the year is used as an environmental variable, accounting for heterogeneity in the sample.

CHAPTER 4: CALCULATION OF EFFICIENCY FRONTIERS

4.1. Introduction

The first stage of applying the benchmarking methods entailed filling in as many of the data gaps and correcting as many of the obvious errors as was feasible. The study uses cross-sectional data for 88[3] South African WSP municipalities for the 2013/14 financial year. A huge challenge experienced in the compilation of the dataset was the gaps in the data – even the complete lack of data – for some municipalities. For this reason, certain municipalities were omitted. Inconsistences in available datasets were also observed; for example, a complete dataset for one variable could be available for 2012, while the same variable might not have any data available for 2013. In spite of all the data-gap challenges, some accurate and reliable datasets were obtained from the electronic database of Statistics South Africa and the DWS.

Local government in South Africa is made up of municipalities of various types. Although there are several types, in the main they can be divided into two groups, namely the largest metropolitan and district municipalities. The former are characterised by the largest metropolitan areas, which are governed by metropolitan municipalities. The latter consist of several local municipalities. As far as service delivery is concerned, municipalities are divided into the following categories:

- A = Metropolitan municipality;
- B1 = Local municipality, with a large town or city as its urban core;
- B2 = Local municipality, with a medium town or towns as its urban core;
- B3 = Local municipality, with a small town or towns as its urban core;
- B4 = Local municipality with no urban core.

The constructed dataset is shown in Table A1 in the appendix.

[3] Although the dataset in table A1 comprises of 147 municipalities, due to missing data our model makes use of only a sub-set of 88 municipalities.

4.2. Discussion of the Data and Descriptive Statistics

The dataset encompasses all WSAs, which includes WSAs providing water, and other municipalities providing part of, or the full, water service on behalf of a WSA. Municipalities that provided the full water service were accounted for by having a higher level of water output and inputs used, relative to municipalities that only perform a part of the function or only supply to specific areas. The efficiency scores generated will therefore reflect the number of inputs used and outputs produced, ensuring that the final assessment of WSA performance accounts for the intuitional arrangement in water service delivery.

The use of SFA and DEA in computing a production function also benefits the benchmarking analysis, by making other features of the institutional set-up of water delivery negligible. For example, municipalities that treat their own water are likely to have different bulk water costs compared to municipalities that purchase bulk water from water boards. Using total bulk purchases as an input will probably account for the different prices seen. Furthermore, the provision of the FBW policy results in higher costs when delivering water, but is unlikely to impact on the total water output of a WSA, as water is delivered regardless of whether the cost is recovered or not. Using a production function with physical inputs and outputs thus makes the size and method of FBW provision irrelevant.

Water losses occur during the provision of water services to customers. They may be due to various inefficiencies on the part of the WSA, including leakage at transmission and distribution mains and inaccurate billing. Such water losses demonstrate a major inefficiency in the system. By using total water consumed by customers as the output in the analysis, the efficiency scores generated will take high water losses into account. The inputs used to produce water are relative to water output minus water losses, meaning that the water output used in the analysis is likely to be lower relative to the inputs used if water losses are high. Municipalities with high water losses are likely to get lower efficiency scores. The descriptive statistics for the variables used in the analysis are given in Table 1 below:

Table 1: Descriptive statistics

Variable	Measurement unit	Obs	Mean	Std. Dev	Min	Max
Q (Output)	Kilolitres/p.a.	88	25 510 198	60 528 617	482 117	352 151 845
L (Input)	Number	88	243	553	5	3 422
B (Input)	Rands/p.a.	88	140 461 674	447 505 919	28 000	3 249 631 000
K (Input)	Kilometres	88	1 656	2 751	46	12 478
Pop (Control)	Number	88	461 666	848 809	12 061	4 503 573

Water output (Q) is the total quantity of water supplied by each municipality during the 2013/14 fiscal year. The authorised consumption expressed in kilolitres (kl) per annum was used to account for water output. The DWS defines authorised consumption as the total volume of metered and/or non-metered water that is taken by registered customers, by the water supplier itself, or by others who are implicitly or explicitly authorised to do so by the water supplier, for residential, commercial, industrial or public purposes. It includes water exported, and may also include items such as fire-fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, and building water.

As mentioned, this amount excludes water losses. Authorised consumption data wasobtained from the No Drop Report produced by the DWS. Table 1 shows that the mean quantity of water supplied by the 88 WSAs was 22 500 000 kl, with a higher standard deviation of 60 500 000 kl. The municipality providing the least quantity of water during the year supplied 482 117 kl, while the one which distributed the highest quantity of water supplied 352 000 000 kl.

The labour input in the production function is measured by the number of both full-time and part-time water services employees, excluding managers. This data was obtained from Statistics South Africa's 2013 non-financial census of municipalities. Table 1 above shows that the average number of employees in the water department of a municipality in the sample is 243, with a standard deviation of 552. The minimum is a municipality with five water-related employees. (This is surprisingly low, given that it takes a considerable number of employees to operate a water service, even if a municipality is small. This number is probably explained by a shared services cost model being used in this municipality; it is likely that certain positions, such as engineers, are shared across services. This is most apparent in smaller municipalities, due to the smaller scope of services delivered and the need to save on salaries. (It would be interesting to establish whether the shared services model is generating efficiencies in such municipalities.) The maximum is a municipality with 3 422 employees in the water department.

The ‘material’ used in the provision of water services is bulk purchases made by each municipality. This is measured in South African rands, and is obtained from the financial reports collected by the National Treasury, required by Section 71 of the Municipal Finance Management Act. The majority of WSAs purchase bulk water from water boards. In 2013/14 there were 12 water boards providing bulk water to municipalities across the country. There are also municipalities that have their own water resources, and which do not buy bulk from water boards; while others produce only some of their water, and buy the rest from a water board. In addition, some municipalities buy from more than one water board, while others buy from water boards outside of their provinces. Using the total bulk water purchases made by a municipality is likely to account for these intricacies, as such purchases would constitute the total value of the bulk water, regardless of where or how it was purchased. Municipalities that use a cheaper method of obtaining bulk water would probably appear relatively more efficient in the analysis. The descriptive statistics in Table 1 above show that the average cost of bulk water purchased for the 88 municipalities is R140 461 674 with a standard deviation of R447 505 919. The lowest bulk water purchase was R28 000, while the municipality with the maximum purchase spent over R3 billion.

Length of mains (MAINS) is the total length of water pipes (expressed in kilometres) owned by each municipality in a particular year, and represents the capital required to deliver water services. The length of the water pipes owned is a relative measure of the size of each municipality. The 2013/14 data on the length of mains were obtained from the No Drop Report produced by the DWS. Table 1 above shows an average of 1 656 km for the 88 municipalities, with a slightly higher standard deviation of 2 751 km. The municipality with the shortest length had 46 km of mains, while the municipality with the most had 12 479 km.

As stated, the municipalities in the sample vary greatly in size as well as in social and economic context. These factors are likely to impact on the estimation analysis and will probably contribute to heteroscedasticity. In order to solve for this, population served (POP) was used as a control variable, regressed on the efficiency scores generated. 'Population served' is the number of people served by water services provided to that municipality during the 2013/14 fiscal year. Data on population served was obtained from the No Drop Report produced by the DWS. Table 1 above shows that the average population served was 461 665 people, with a higher standard deviation of 848 809. The municipality serving the least number had a population of 12 061 people, while the municipality with the highest population served had 4 503 573 people. The wide variation in the value of this variable is confirmation of the differences across the municipalities in the sample.

Lastly, dummy variables was also be used to control for the different municipalities in the sample. Dummies equalling 1 for a metro, district and secondary city were included in the analysis, with local municipalities acting as the reference group.

SFA theory prescribes that when estimating technical efficiency, cost is expressed as a function of output and input prices. Some studies use the average water provision cost (see Souza et al., 2007) while others use variable cost (see Aubert and Reynaud, 2005). Several studies in the literature use total water provision cost (see Filippini et al., 2007; Baranzini et al., 2010; and Horn and Saito, 2011). The volume of water provided to consumers has been widely used in the SFA literature to reflect output (see Souza et al., 2007; Filippini et al., 2007). There is widespread consistency in the SFA empirical literature on the use of the price of capital, price of labour, price of materials (see Filippini et al., 2007; Horn and Saito, 2011), and sometimes energy price (Baranzini et al., 2010). SFA allows researchers to add environmental variables that are not within the control of utilities, but which can affect performance. These variables are infinite in number, so researchers must use their discretion. Commonly used environmental variables include population (Aubert and Reynaud, 2005; Filippini et al., 2007), population density (Horn and Saito, 2011), length of pipe network (Vishwakarma and Kulshrestha, 2010) number of customers, and many others.

Unlike in the mentioned SFA studies where efficiency is estimated using total cost as a function of output and input prices (thus estimating cost efficiency), this project estimates technical efficiency. As such, the Cobb-Douglas production function is estimated where the quantity of water provided is expressed as a function of physical units, which are the quantity of labour, materials and capital.

In DEA theory, total cost (Carvalho et al., 2015; Cruz et al., 2013) can be used as output against physical units as inputs. Although researchers may determine for themselves which variables to use, depending on sectoral circumstances, most studies in the water and wastewater sector use water output, number of connections served and length of mains (see Brettenny and Sharp, 2016; Guerrini, et al., 2015; Carvalho et al., 2015). Other variables used as inputs include number of employees (see De Witte and Marques, 2010) and number of customers (Guerrini et al., 2015; Cruz et al., 2013). Variable selection in our study was guided by the empirical literature. Table 2 below gives a detailed overview of some of the studies in the literature that have used SFA and DEA, as well as the variables they chose.

Table 2: Summary of the empirical literature reviewed in this section

Stochastic Frontier Analysis (SFA)			
Author(s)	**Data sample**	**Variables used**	**Findings**
Souza, Faria and Moreira (2007)	Brazilian water supply utilities Number: 279 Year 2002	Average cost, water output, price of capital, price of labour, capital, labour, average tariff and average profit	Efficiency measurements are not significantly different between private and public firms.
Baranzini, Faust and Maradan (2010)	Swiss water utilities Number: 330 Years: 2000-2005	Total cost, output, unit variable costs (labour price, energy price, material price and capital price), and environmental variables (customer density, load factor, pumped water, type of customers and water adduction)	Exogenous factors affect the efficiency of water utilities less than endogenous factors.
Filippini, Hrovatin and Zorić (2007)	Slovenian water utilities Number: 52 Years: 1997-2003	Total cost, water output, price of labour, price of material, price of capital, number of customers served, the size of the service area, and exogenous variables (water losses, water treatment, use of surface water, use of underground water, and changes in technology)	Significant cost inefficiencies were found in the water utilities, and an incentive-based price regulation scheme was recommended.

Stochastic Frontier Analysis (SFA)			
Author(s)	**Data sample**	**Variables used**	**Findings**
Horn and Saito (2011)	Japanese water utilities Number: 831 Years: 1999-2008	Total cost, water delivery volume, network characteristics, labour price, capital price, and exogenous variables (network density and time trend)	Average cost inefficiency was high at about 37 per cent.
Vishwakarma and Kulshrestha (2010)	Cities in the State of Madhya Pradesh, India Number: 18	Average daily water production, staff per thousand connections, length of the piped network, installed production capacity, density of customers, and water losses	Some utilities perform better than others.
Aubert and Reynaud (2005)	Wisconsin water utilities Number: 211 Years 1998-2000	Variable cost, volume sold, number of customers, price of labour, price of electricity, and capital	Utilities' efficiency scores were partly explained by the regulatory framework.

Data Envelopment Analysis (DEA)			
Authors	**Data sample**	**Variables used**	**Findings**
Brettenny and Sharp (2016)	South African rural and urban water service authorities Number: 88 Data for the 2009/2010 financial year	Operating costs, number of connections served, length of mains (dispersion), water delivered to clients (metered and non-metered), measured amount of water delivered, estimated remainder of water delivered, and expenditure incurred for repairs (pipe bursts)	Average technical efficiency was 0.636 for urban municipalities and 0.526 for rural municipalities.
Guerrini, et al. (2015)	Danish wastewater utilities Number: 62 Year: 2010	Operation costs, transport costs, treatment costs, customer handling costs, sewage volume treated, sewer length, population served, and population density	Firms operating in very high density areas were more efficient, and those that managed both water and wastewater saved costs by vertical integration.
Carvalho, Pedro and Marques (2015)	Brazilian water utilities Number: 4900 Years 2001 to 2011	Total expenditure, volume of drinking water billed, and volume of treated wastewater	Utilities providing both drinking water and wastewater services were more efficient than those that only provide the drinking water services. Local utilities were more efficient than regional utilities. Utilities with private participation were more efficient than those with no intervention by any private entity in their management.

Data Envelopment Analysis (DEA)			
Authors	**Data sample**	**Variables used**	**Findings**
Cruz, Carvalho and Marques (2013)	Portuguese water utilities Number: 45 Years 2002 to 2008	Total costs, water customers, and wastewater customers	No statistical significant difference between the efficiencies of drinking water services and wastewater services. Operators providing retail and wholesale drinking water and wastewater services have higher cost efficiencies for both services.
De Witte and Marques (2010)	Netherlands, England and Wales, Australia, Portugal and Belgium.	Average number of employees, average length of mains, average volume of water, average number of connections, and connections per employees	Large differences in bias and noise-corrected first-stage inefficiencies. Benchmark incentive schemes have a positive effect on efficiency.

4.3. Stochastic Frontier Analysis Results

Three SFA production functions were estimated. The results of these models are presented in Table 3 below.

Table 3: Stochastic frontier results

Water Output (lnQ)	Model 1	Model 2	Model 3
lnB	0.0821**	0.0732**	0.0677**
	(0.0336)	(0.0335)	(0.0294)
lnK	0.627***	0.512***	0.549***
	(0.0893)	(0.107)	(0.101)
lnL	0.278***	0.265***	0.267***
	(0.0793)	(0.0798)	(0.083)
Constant	9.603***	10.49***	10.36***
	(0.486)	(0.606)	(0.491)
Inefficiency Term			
lnpop		-0.935*	-0.427
		(0.478)	(0.408)
city			-30.2
			(3,025)
district			0.53
			(1.336)
Constant	-1.376	9.283*	3.888
	(1.394)	(5.18)	(4.587)
Error Term			
lnpop		0.212	0.464
		(0.205)	(0.293)
city			-1.882**
			(0.767)
district			-0.0213
			(0.882)
Constant	1.313***	-3.961	-6.811**
	(0.48)	(2.637)	(3.409)
Observations	88	88	88

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Model 1 is the SFA estimation using one output and three inputs, and assuming a half-normal distribution in the error term. In this estimation, it is assumed that there is no heteroscedasticity in the error and efficiency term. Therefore, heteroscedasticity was not corrected for in Model 1. In Model 2, a half-normal distribution of the inefficiency term was also assumed, but here we assume that there is heteroscedasticity in the error and efficiency term. To remedy this, the model controls for the variation of the error and efficiency term with the size of the population served by each municipality, assuming the heteroscedasticity is driven by the sizes of the municipalities. This is shown in the simultaneous regressions undertaken at the bottom half of the table. Model 3 extends the control variables on the error and efficiency scores to include dummies for the different types of municipalities.

The variables used in the production function of all three models are statistically significant, and have a positive impact on water output. This conforms to theory, as an increase in labour, capital and material inputs would probably increase output. On the inefficiency term, Model 2 suggests that an increase in population served results in a decrease in the inefficiency score. This result is statistically significant, and confirms the impact the size of a municipality can have on the efficiency scores. The result suggests that Model 1 was possibly not capturing the efficiencies that were generated by serving a larger population group. In Model 3, the variables used to control for municipal size are not statistically significant in explaining the variation in the inefficiency term. This is surprising, but may suggest that a better-specified efficiency function needs to be estimated.

The efficiency scores were calculated for each of the three models above. These results are presented in Table 4 below.

Table 4: Summarised efficiency scores from SFA model

Efficiency Scores	Observations	Mean	Standard Deviation	Minimum	Maximum
Model 1 Scores	88	0.70	0.09	0.42	0.88
Model 2 Scores	88	0.73	0.16	0.29	0.94
Model 3 Scores	88	0.73	0.20	0.27	1.00

The average efficiency scores across all models range from 0.7 to 0.73. In other words, the WSAs in the sample can maintain the same level of water output with between 30% and 27% less input. In Model 1, the lowest efficiency score is 0.42, while the highest is 0.88. When accounting for population and municipal type in Models 2 and 3, the minimum efficiency score decreases while the maximum efficiency score increases. This suggests that in Model 1, certain municipalities with lower population numbers were deemed relatively more efficient, while municipalities with higher population numbers were deemed relatively less efficient. This is probably due to smaller municipalities with lower inputs being compared to larger municipalities. Such results highlight the importance of accounting for the sizes of DMUs, given the heterogeneous nature of South African municipalities. Figure 10 below plots the different scores generated across municipalities.

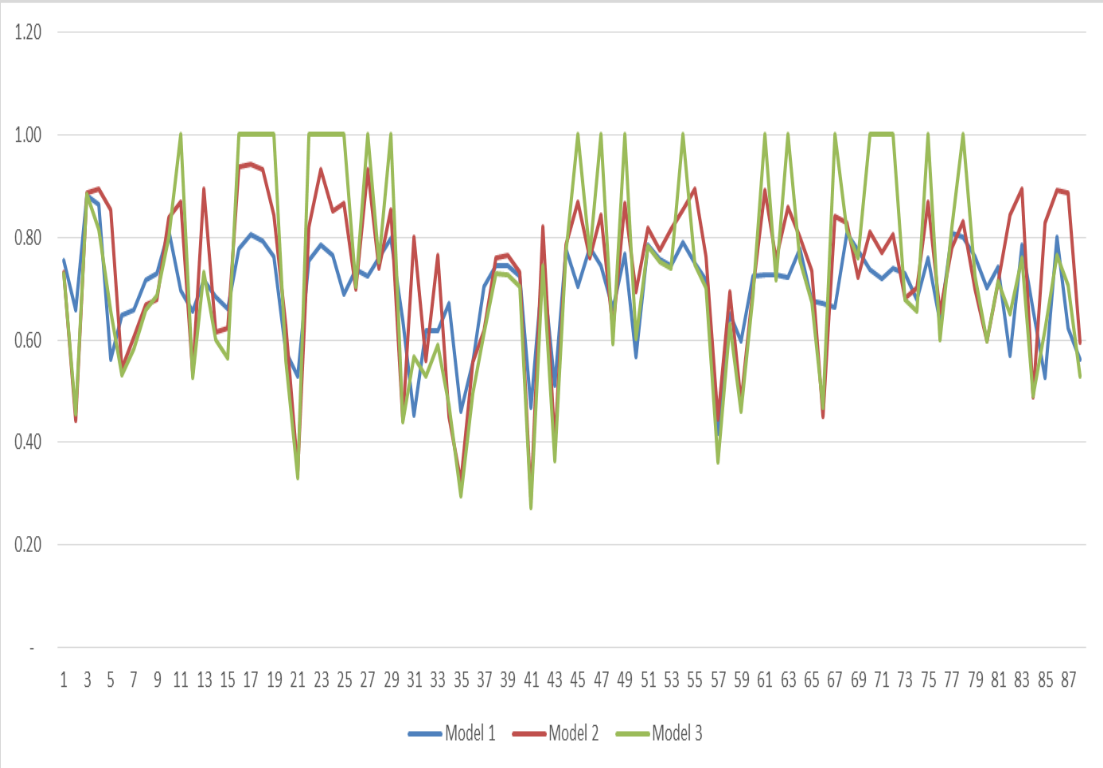


Figure 10: Generated scores for municipalities

Figure 10 allows one to see the deviations in the scores generated by each model. In general, it appears that municipalities at the extremes in Model 1 (i.e. with relatively higher or lower scores) had such extremes increased in Models 2 and 3. There also seems to be a greater variation in the scores generated by Model 3, which is confirmed by the higher standard deviation of these scores, in Table 4 above.

Ultimately, the aim of the SFA analysis is to benchmark performance – to establish, from the scores generated, which municipalities or WSAs are better performing or more highly ranked, relative to others. From the analysis above, it is clear that the SFA method is dependent on the assumptions attached to each model, even though there is some consistency in the scores. Generating the appropriate SFA model to benchmark performance is thus dependent on the nature and context of the DMUs in question. It is clear that the sample in this analysis is quite diverse, necessitating the need to account for the different sizes of municipalities. Therefore, the scores generated from Models 2 and 3 should be more appropriate for benchmarking, compared to the scores generated in Model 1. However, when judging performance, one must then decide whether to use Model 2 or Model 3.

The choice of model can be based on the econometric results generated, particularly the coefficients on the efficiency term. As indicated in Table 3 above, when looking at the inefficiency term, the population variable is significant in Model 2, while the coefficients on Model 3 are not significant. Based on this analysis, Model 2 is the most appropriate for benchmarking performance.

Despite the different specifications implemented, to a large degree the results converge. This implies that the results are robust and consistent with each other. Overall, the slight differences observed in the results across the three models are explained by control variables (exogenous framework conditions), e.g. the difference in population sizes. Model 3 confirms that adding more controls (such as whether the WSA is a city or not, or a district or not) to a population, as done in Model 2, adds no value, as it does not influence the effectiveness of WSAs with respect to water provision. Model 1 fails to control for other factors in the model, which gives rise to possible biases. On this basis, Model 2 is preferred.

4.4. Data Envelopment Analysis Results

The SFA results above play an important role in finding the most appropriate method for benchmarking municipal performance. They also show that any benchmarking method used – be it simple descriptive statistics, single and multi-dimensional indices, or complex efficiency techniques – needs to take into account the large differences between municipal WSAs in South Africa. Therefore, more robust methods (such as the SFA explicitly accounting for the different sizes of municipalities) are the most appropriate way to benchmark performance.

This section presents the efficiency scores generated by the DEA method. One of the concerns with DEA is its susceptibility to outliers and variation in the sample used. Given the varying contexts of South African municipal WSAs confirmed in the SFA models above, in a DEA analysis one would need to try and minimise the variation across the sample. As a result, DEA analyses were undertaken by splitting WSAs into different categories (i.e. metropolitan and secondary cities, and district and local municipalities).

It was assumed that grouping municipalities with similar characteristics would minimise the variation in these groups. In addition, VRS assumptions were placed on the DEA analysis, it being assumed that municipalities are at different stages in their production processes. For comparison purposes, DEA was also estimated for the entire sample; but it is important to note that the scores generated cannot account for differences across municipalities. Table 5 below lists the descriptive statistics from these results with the SFA estimation for Model 2 for comparison.

Table 5: Descriptive statistics for DEA scores

Efficiency Scores	Observations	Mean	Standard Dev.	Minimum	Maximum
DEA – Whole Sample	88	53.68%	29.79%	8.30%	100.00%
DEA – Grouped	88	69.15%	28.97%	15.14%	100.00%
SFA – Model 2 Scores	88	0.73	0.16	0.29	0.94

When DEA was estimated for the sample collectively, the average score was 53.7%, suggesting that WSAs in the sample could maintain the same output with just under half of the resources used currently. However, when municipalities were grouped in order to account for their differences, the average efficiency score increased to 69%. This indicates that there is a large variation in the contexts of municipalities in the DEA analysis. This is probably due to this method deeming relatively smaller municipalities inefficient, when compared to their larger counterparts. The mean efficiency score generated by the DEA analysis when municipalities were grouped is comparable to the mean value of the efficiency score generated using Model 2 in the SFA method. Table 6 below is a list of the most efficient municipalities, generated when DEA was applied first to the entire sample and then to grouped municipalities.

Table 6: Efficient municipalities from DEA analysis

Category	Municipality	DEA - VRS - ALL	Municipality	DEA - VRS - Individual	Category
B2	//Khara Hais	100.00%	//Khara Hais	100.00%	B2
C	Amajuba	100.00%	Amajuba	100.00%	C
B2	Breede Valley	100.00%	Breede Valley	100.00%	B2
A	City of Cape Town	100.00%	City of Cape Town	100.00%	A
A	City of Johannesburg	100.00%	City of Johannesburg	100.00%	A
A	City of Tshwane	100.00%	City of Tshwane	100.00%	A
B3	Hantam	100.00%	Emthanjeni	100.00%	B3
B3	Khai-Ma	100.00%	Govan Mbeki	100.00%	B1
B2	Moqhaka	100.00%	Hantam	100.00%	B3
B3	Ramotshere Moiloa	100.00%	Joe Gqabi	100.00%	C
B3	Richtersveld	100.00%	Khai-Ma	100.00%	B3
B3	Thembelihle	100.00%	Mafikeng	100.00%	B2
B3	Tsantsabane	100.00%	Makana	100.00%	B2
C	Uthungulu	100.00%	Mbombela	100.00%	B1
C	Vhembe	100.00%	Mopani	100.00%	C
B3	!Kheis	92.88%	Moqhaka	100.00%	B2
B3	Siyathemba	90.87%	Nelson Mandela Bay	100.00%	A
A	Ekurhuleni Metro	90.52%	Ramotshere Moiloa	100.00%	B3
C	Mopani	89.48%	Richtersveld	100.00%	B3
A	Nelson Mandela Bay	89.48%	Saldanha Bay	100.00%	B2
B3	Emthanjeni	81.76%	Stellenbosch	100.00%	B1
B3	Bitou	80.23%	Thembelihle	100.00%	B3
B2	Makana	79.47%	Tlokwe	100.00%	B1
C	Umgungundlovu	76.16%	Tsantsabane	100.00%	B3
B3	Kou-kamma	75.35%	Umgungundlovu	100.00%	C
B2	Saldanha Bay	72.53%	Uthungulu	100.00%	C
B3	Dikgatlong	71.40%	Vhembe	100.00%	C

Unsurprisingly, the DEA analysis applied to grouped municipalities generated a list of very efficient municipalities. This was due to certain production functions being estimated that were municipal-type-specific, which would result in certain municipalities appearing efficient when compared to similar peers, as opposed to larger municipalities that are essentially operating at a different level of production. Nonetheless, there appears to be some correlation between the municipalities deemed efficient by each method. However, if one wants to compare performance between peers, then it is best to group municipalities that are comparable in terms of size and production processes.

Figure 11 below shows the results of the DEA analysis across the cities and district municipalities. Also included in the analysis are the efficiency scores generated by Model 2 in the SFA method.

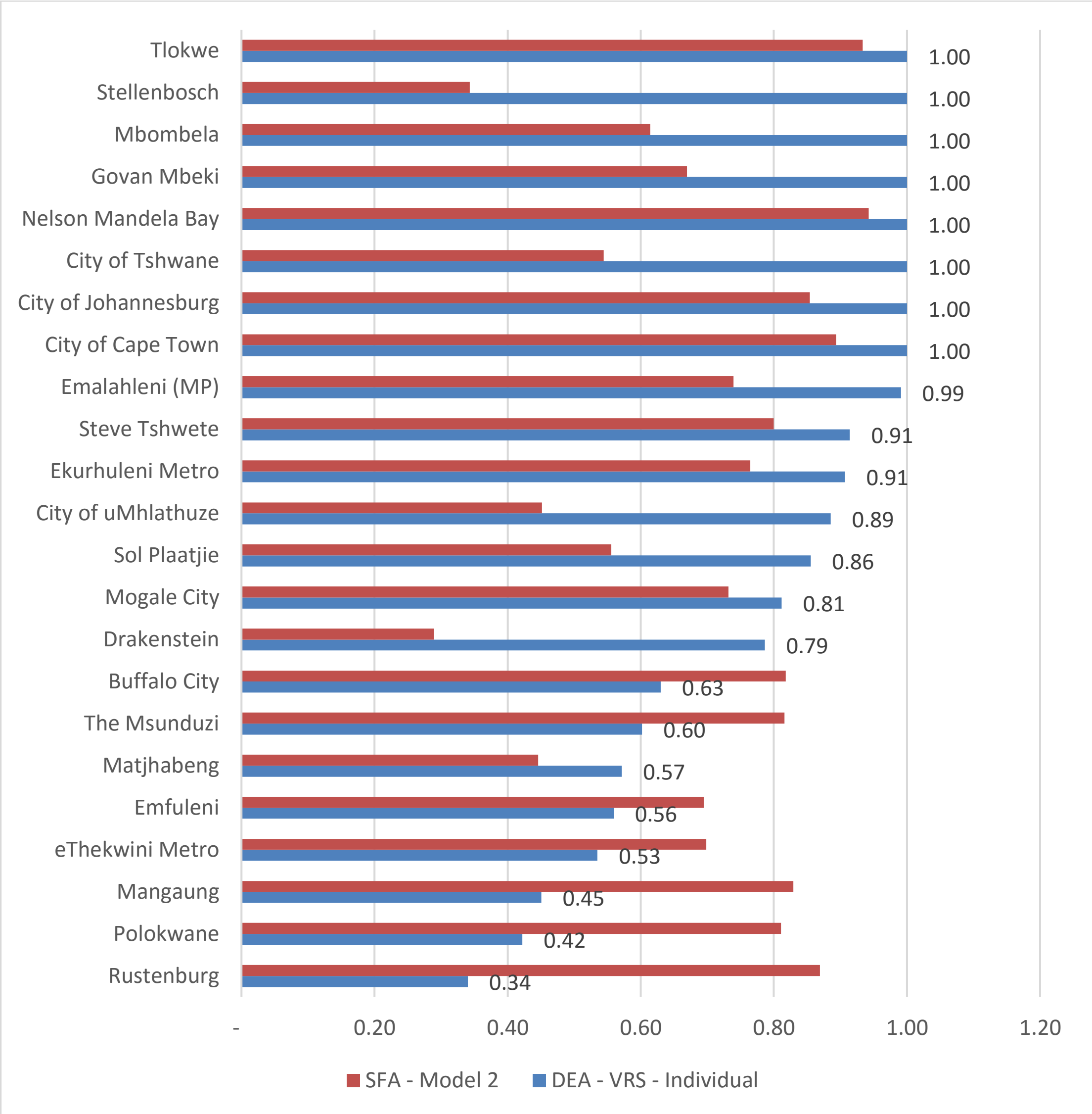


Figure 11: **DEA efficiency estimates for cities (metros and secondary cities)**

The results in Figure 11 above suggest that there is not a very strong correlation between the efficiency levels generated by DEA and SFA. This is understandable, given the context of the analysis. Firstly, it is likely that there is great variation in the operating contexts of the municipalities, even within the grouped sample. For example, although Rustenburg municipality is considered a secondary city, it is largely incomparable with a large metro such as the City of Johannesburg. This could explain the differences seen in the scores; the SFA method accounts better for differences between municipalities.

This is one of the major disadvantages of the DEA method, when applied to heterogeneous DMUs. Even though in DEA we tried to solve heterogeneity across municipalities by grouping, it appears the DEA scores still exhibit differences across DMUs.

Secondly, and more importantly, the difference in efficiency scores essentially confirms that the SFA and DEA methods must be undertaken and subsequently analysed in the specific context of the DMUs in question. In other words, the context of the comparisons must be taken into account when analysing the results from each method. The SFA analysis compared all WSAs, taking into account the size and scope of all municipalities depending on the production function specified. Therefore, for example, Amajuba district municipality is more efficient than a smaller local municipality when a production functional relationship is specified, but less efficient when compared to another, more efficient district municipality, based on how the latter uses inputs to produce outputs. The DEA analysis uses a different benchmark for comparison, namely the municipality on the efficiency frontier. Efficiency estimates are likely to be different given the different benchmarks used. Such differences are perfectly justified, as the contexts of the comparisons are different.

However, this makes it difficult to benchmark performance, as there must be certainty as to what to use as the benchmark. If one wants to compare peers that are homogenous in their production process and operating contexts, then the DEA method is most appropriate. But if one is faced by large DMUs with great variation in operating context, it is best to specify the production function and account for such differences. With that said, there should still be a degree of correlation between the scores, particularly in the ranking of performance. However, the results in Figure 11 above suggest otherwise. It is likely that the DEA method suffers from an inability to account appropriately for the differences between South African municipal WSAs, even within specific categories.

4.5. Conclusion

Growing pressure on water resources from climate change, rapid population growth, the pursuit of economic growth and other factors has significant implications for social, economic and environmental well-being. As a result, water utilities are facing serious challenges as they strive to increase water quality, lower the cost of water provision, expand their piped network, and manage ageing infrastructure and financial constraints. Benchmarking has become a key instrument in the water sector, used to promote efficiency, achieve performance targets and encourage competition. It incentivises water utilities to constantly pursue performance improvements.

Difficulties are often encountered when comparing the performance of water utilities, even within the same country; there are probably even more when comparing across countries, including differences in topography, the availability of water resources, per capital gross national product, and differences in the cost of resources. When performance comparisons are made, therefore, one should be aware of contextual differences between utilities. Furthermore: in developing countries such as South Africa, a lack of reliable and verifiable data may compromise the validity of any comparisons, or the use of such data.

The study was able to trace and capture information for 88 South African municipalities. This dataset enabled us to undertake a performance assessment analysis. SFA and DEA techniques were used to estimate the technical efficiencies of South African WSP municipalities. Cross-sectional data for the 88 municipalities from the year 2013 was used. Data was obtained from the DWS, and Statistics South Africa.

Thus, SFA and DEA was used to obtain technical efficiency scores. Even though there is no strong correlation, the SFA scores somewhat correlate with those obtained by DEA, which increases our confidence in our analyses of the efficiency of South African municipalities. Overall, results from the study reveal an average inefficiency score of 0.31. This implies that, on average, South African WSP municipalities are 31% inefficient. The results also imply that improvements could be made to the two tools used in this report. This will improve their usefulness for generating WSA efficiency scores.

CHAPTER 5: PERFORMANCE MEASUREMENT CONCLUSION AND RECOMMENDATIONS

5.1. Benchmarking

Benchmarking is a systematic search for best practices that will lead to superior performance. Many sectors – including the water sector – are beginning to look at benchmarking as an instrument to assist them in achieving better results for less. There has been increasing interest in the ability of different methods to measure the relative efficiency of WSAs over their inefficient counterparts. This study employs two different approaches (SFA and DEA) that have been widely used to assess efficiency. Deriving from this context, the objectives of this report are to provide an overview of benchmarking techniques, and to identify the most appropriate benchmarking tool for South African WSAs.

SFA is an econometric/statistical tool which uses regression analysis to estimate a conventional cost function, with the difference being that the efficiency of a WSA is measured using the residuals from the estimated equation. The error term is decomposed into a stochastic error term (i.e. noise) and a systematic inefficient term (i.e. inefficiency).

The second technique, DEA, is a linear programming tool which enables the measurement of efficiency scores consistent with the theoretically-based concept of production efficiency. The technique entails assessing the link between inputs to a production process (resources used by WSAs) and the outputs of that process (for example, costs associated with water provision). In this study, labour, bulk water purchases, length of pipes used and population served are used as the inputs. In other words, DEA assesses the question: 'By how much can costs be reduced without changing the output quantities produced by the WSA?'

The basic research aim for this report then becomes: 'Which of these two methodologies can best be employed to measure efficiency in WSAs, and do the different methods produce consistent efficiency scores?'. To answer this question, we use benchmarking data from the South African water sector, applying both SFA and

DEA methods. The same variables are used so as to make the two methods as comparable as possible, and we then evaluate the efficiency scores that each method produces. We managed to trace and capture information for 88 WSAs. This dataset enabled us to undertake some performance assessment analysis. Both methods used the same dataset.

To an extent, the SFA scores correlate with those obtained by DEA, which increases our confidence in our analysis of the efficiency of WSAs. The efficiency scores should not be interpreted as revealing the absolute efficiency of each WSA, but rather the relative efficiency of each WSA when compared to the others. Although the two methods are complementary in nature, SFA is deemed to be the best methodology, due to its ability to control for other factors that drive results (such as differences in population size, and types of WSA, e.g. metro or small municipality). Most importantly, the inefficiency measured by SFA is divided into noise and inefficiency. It should be noted that these methods are sensitive to model specification, measurement and data errors – as well as outliers, which are common in benchmarking models.

The two methods (SFA and DEA) used in this study have different strengths and weaknesses. The advantage of DEA is that it measures efficiency only, relative to the highest observed performance rather than an average. However, due to its deterministic nature, it is sensitive to measurement errors or other noise in the data; hence, all deviations from the relative frontier are attributed to inefficiencies. On the other hand, the strength of SFA lies mainly in its ability to account for stochastic noise in data. Its main drawback is that it requires the explicit imposition of a particular parametric functional form representing the underlying production, as well as an explicit distributional assumption for the inefficiency terms.

The results show the statistically significant impact of external factors on the efficiency of South African WSAs; but more importantly, they highlight the significance of paying particular attention to the way unobserved heterogeneity is treated. The South African WSAs are very heterogeneous and operate in very different conditions, most of which vary very little over time. Due to data and econometric constraints, it is impossible to control for variables that would account for all these differences. This favours SFA as the model of choice. Wide differences in scores show the sensitivity of results to modelling specification, which consequently emphasises that if SFA is to be used for regulation, alternative models should be tested; and that even though econometric benchmarking can be an effective tool, it should be complemented by further analysis.

In conclusion, the comparative analysis indicates that the relative performance of the stochastic frontier models vis-a-vis DEA relies on the choice of functional forms. If the employed form is close to the given underlying measure, stochastic frontier models outperform DEA using a number of metrics. Most importantly, if the misspecification of the functional form was to become more serious and the degree of correlatedness of inefficiency with regressors increases, DEA's appeal would become more compelling. This report has provided at least some useful insights into efficiency in this important sector and how South African WSAs operate in increasingly regulated and demanding environments.

5.2. Recommendations

Based on the attempts in this study to compare the two methods, we make the following recommendations:

- Due to the sensitivity of both methods to outliers, several specifications should be used to identify the underlying general trends pertaining to which WSA is more efficient, and which ones emerge as inefficient;
- Both methods should be used as signalling devices. No policy response should take place based on just an exploratory investigation, such as the one undertaken in this report;
- The calculation of actual degrees of inefficiency for WSAs, any policy responses and the sanctioning of appropriate action must only be made after more detailed investigations;
- While the two methods used in this study are very useful diagnostic tools, it would be inappropriate to base funding and resource decisions solely on the basis of the efficiency estimates arrived at in this report;
- Ultimately, data accuracy is paramount for any analysis including SFA and DEA, as inaccurate data will affect the scores generated;

- Improvements in the data would certainly increase the usefulness of the models used in this study, which were to a large extent constrained by both data quality and data availability;
- WSA input and output information should be made available using an interactive reporting tool, and this information should meet the needs of the benchmarking process.

5.3. Future Research

There seems to be a gap between academics, who seek robust and more advanced econometric and other quantitative techniques, and practitioners, who should be able to communicate study results to key stakeholder groups. This issues deserves more attention in future research. Despite important insights from this study, there are at least several ways in which this research could be extended.

Future research should expand the dataset used. SFA based on cross-sectional data such as the dataset in this report is hampered by the fact that it is based on only one observation for the estimation of two error components. Future research should use panel data. Panel data containing several observations for each WSA will significantly improve the WSA-specific efficiency scores. Future research should also use DEA in a panel data setting.

There is a need to investigate factors that influence the efficiency/inefficiency residual, by adding further information – hence the need for a more comprehensive dataset, for example, including change of governing parties, staff composition, quality of service, financial sustainability, and factors that influence economic efficiency. Similarly, studies looking at the relationship between economic performance and the environment and water scarcity are fairly thin on the ground. Moreover, there is a need to undertake process benchmarking as it links with performance improvement. Performance improvement investigates the underlying differences between the processes and methods being used and policies. Moreover, processes can be compared between utilities and also within a utility (e.g. within a water service provider, relating to billing and revenue collection).

The results suggest that measures of efficiency are fairly sensitive to the choice of methodology. This sensitivity (resulting from applying different model specifications, or changes due to time periods) compromises the study findings, as they may be called into question if they are actually used in regulatory proceedings. For this reason, future research should consider ways to improve models through the possible inclusion of some alternative variables and assumptions. This should reduce any bias associated with either of the two methods. Ideally, a method that combines the strength of both SFA and DEA into a unified framework of frontier estimations is required. Such a method should be estimated in a panel data setting in a fully non-parametric fashion. More analytical assessments of WSAs are required to enrich the literature on benchmarking of WSAs – especially in developing countries, where assessment frameworks and indicators are not well defined.

SECTION 3 CHOICE MODELLING

CHAPTER 6: CHOICE EXPERIMENTS TO ASSESS SOUTH AFRICAN HOUSEHOLDS' WILLINGNESS TO PAY FOR WATER SERVICE ATTRIBUTES

6.1. Introduction

One of the key challenges facing water service providers in developing countries is the increasing need for access to a safe water supply for a rapidly increasing population. It is well documented that in a significant number of developing countries, water provision (i.e. water supply and sanitation) falls short of current and future requirements. The status of water supply service delivery to households in South Africa is neither well understood nor adequately assessed. The primary aim of Section 3 of this report is to undertake municipal performance assessments relating to how well South African water service packages satisfy present demand.

Water utility performance can be measured by gauging consumers' perceptions of how well their water service packages are meeting their demands. Measuring customer satisfaction can be supplemented by reports from the WSPs themselves, which can offer interesting insights when one WSP is compared with another (Ministry of Urban Development, 2015). Although the ideal would have been to conduct customer surveys, due to budget constraints this study surveyed households in only one of the metropolitan municipalities. A well-run WSA should provide for all customers who demand a service at a level that meets their needs and which they are willing and able to pay for. The focus in this section is on assessment of service quality from the customer's point of view.

The best way to develop consumer-oriented water policies is through assessing whether the current water service packages provided to consumers actually meet their expectations. Establishing consumer preferences and comparing them to the available water service packages is important in policy formulation. Across the world, there has been a growing need to assess consumer preferences for water services. This consumer-oriented approach by water utilities has seen several studies being conducted on consumer preferences in agriculture (see Cook and Rabotyagov, 2014; and Loch et al., 2014), quality preferences (see Martin-Ortega, Brouwer, Ojea and Berbel, 2012; Ahtiainen, Pouta and Artell, 2015) and household preferences (see Bjornlund, Parrack, and De Loe, 2012; Rungie, Scarpa and Thiene, 2014).

In South Africa, a few attempts have been made to elicit consumer water service preferences (see Snowball, Willis and Jeurissen, 2008; and Kanyoka, Farolfi and Morardet, 2008). The scarcity of literature on the subject makes it an ideal choice of subject for researchers that will provide a pool of knowledge for policymakers in the water sector.

Although in some parts of the world the private sector is involved in providing water services, in most countries water supply is provided by public water utilities. In South Africa, all water supply services are currently in the public sector. Constitutionally, the country considers access to water a basic human right, making water both a social and an economic good. In light of this constitutional requirement, municipalities have a responsibility to provide water services to all citizens at affordable tariffs. The increasing block tariff (IBT) system is used by all municipalities. As household water usage increases, the tariff moves to the next-higher block of consumption. There is provision for free basic water for poorer households that cannot afford to pay for water services. Municipalities set the criteria for qualification for free basic water, and these criteria vary between municipalities.

Water provision is associated with many operational costs emanating from bulk water purchases, treatment, storage, transportation and disposal (Eberhard, 2003; EUWI-FWG, 2012). Raising revenue from consumers is central to cost recovery and future up-scaling of water services (Goldblatt, 1999). Statistics reveal that most municipalities in South Africa struggle to raise enough revenue to cover the costs of providing water services. Critics claim that municipalities fail to generate enough revenue from water services because of very low tariffs (see Tsegai, Linz and Kloos, 2009) and inefficiencies (see Westhuizen and Dollery, 2009), while others suggest that municipalities do not properly consult water consumers on their preferences. In most areas, households receive ‘one-size-fits-all’ water services, and do not get value for their money. On the other hand, some scholars blame backlogs created by the exclusive policies of the apartheid era (see Nleya, 2008).

Considering these arguments, and the huge financial losses recorded by municipalities, the question that comes to mind is: ‘How best can municipalities improve in water service provision?’ This is not only essential for raising revenue, but is also useful in sustainable water resources management. South Africa is a water-stressed country, and solutions are required that promote the sustainable management of water resources.

Since households play a key role in water consumption, the essential objective of this study was to establish how households prefer to receive water services. The main object of this paper is to establish households’ preferences for water services, using eThekwini Metropolitan Municipality as a case study. The information in this report is vital, as it contributes to our limited knowledge of how municipalities are performing as far as water provision is concerned. The households’ assessment as to whether the water services they receive from municipalities satisfies their demands is used as a proxy for measuring municipal performance.

6.2. Study Area

Located in the KwaZulu-Natal (KZN) province, the eThekwini metropolitan municipality is the third-largest metropolitan municipality in South Africa, with a population of about 3.6 million people (eThekwini Municipality, 2015b), who live in suburbs, townships, informal settlements and rural areas. Young people (0–14 years) constitute 25.2% of the population, while the working age (15–64 years) make up 70% and the elderly (65+ years) 4.8% of the population (Statistics South Africa, 2011).

A large number of people in the municipality fall into the ‘poor’ and ‘middle class’ groups, with just a few in the high-income groups. In 2015, the official unemployment rate in the municipality was 16.5%, with an expanded unemployment rate of 26.3% (eThekwini Municipality, 2015c). The municipality is one of the fastest-growing in South Africa, and generates most of KZN’s gross domestic product (GDP). Many nonresidents have the perception that the municipality covers only the city of Durban; though Durban is the main economic hub, the municipality extends far beyond the city limits. To explain the full jurisdiction of the eThekwini metropolitan municipality, Figure 12 below is a map of the municipality.

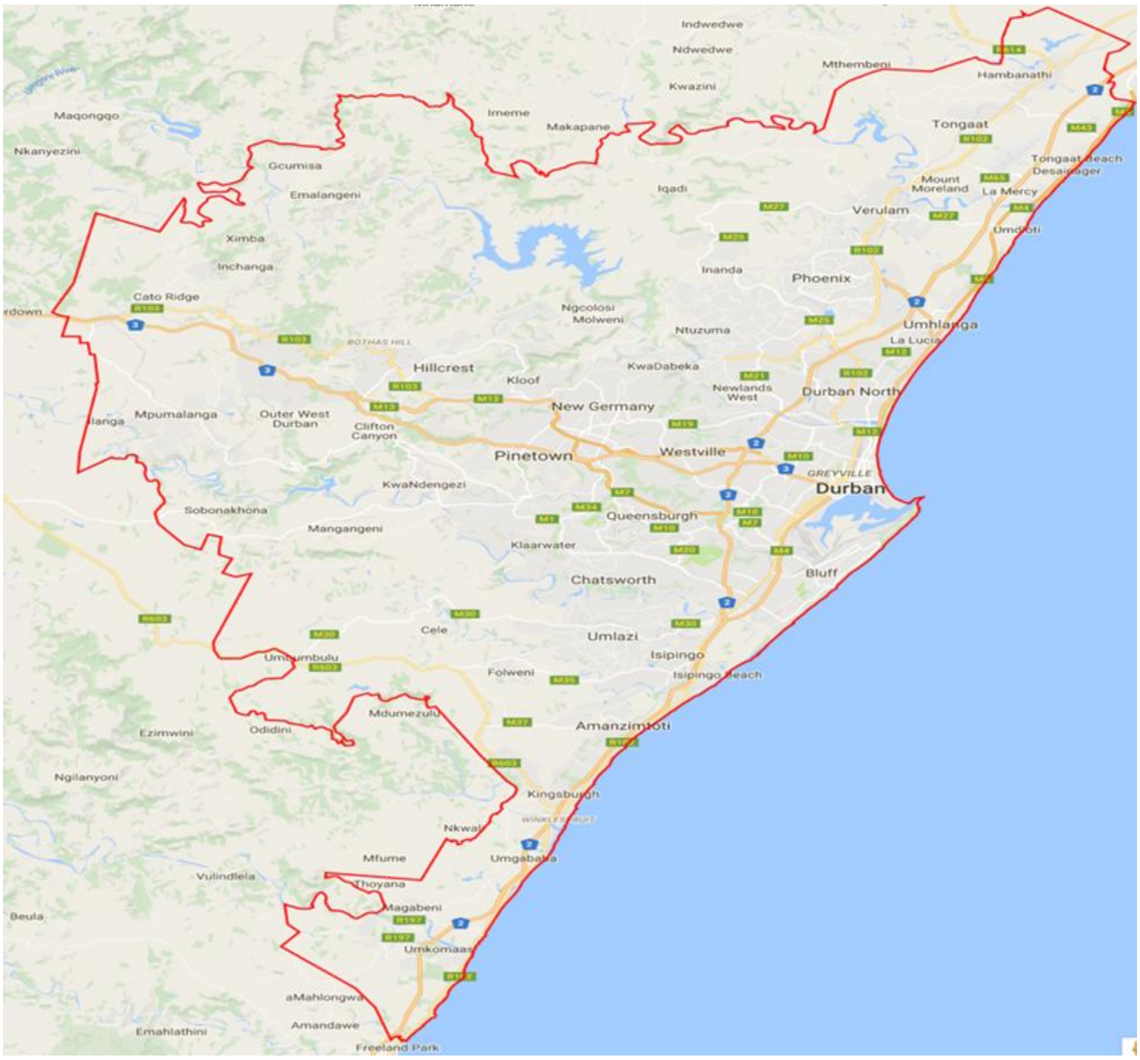


Figure 12: Map of the eThekwini metropolitan municipality (Source: Frith, 2011)

Our study surveyed several areas in the municipality. In Durban, households from Morningside, Musgrave and Overport were surveyed. The survey was also conducted in other suburban areas outside Durban, namely La Lucia, Umhlanga, Verulam and New Germany. For townships, respondents were questioned at Inanda, Ntuzuma, Phoenix, Verulam, Westville, Chesterville, Chatsworth and Umlazi. Respondents from informal settlements in Bhambayi (Inanda) and some sections of Umlazi were also interviewed. Rural households were surveyed in Umbumbulu. Exploring these diverse areas gave us a clear picture of how households receive water in the municipality.

The municipality is the main source of water, providing 90.5% of all the water consumed by households; while the rest use other sources such as boreholes, springs, and rivers or streams (Statistics South Africa, 2011). The minimum standard of water service provision by the municipality is a standpipe provided to serve a community, where the maximum distance from the furthest dwelling to the standpipe is 200 metres (eThekwini Municipality, 2014).

As with most African water utilities (see Espey et al., 1997), the eThekwini municipality uses the increasing block tariff structure to charge for water services. Currently, a distinction is made between five successive blocks, and property-value-based targeting is used to determine those who receive free basic water. Households living in properties valued at less than R250 000 do not pay for any consumption in the first block (up to 9 000 litres of water per month). Statistics show that a sizeable number of households in the municipality do not have piped water inside their dwellings. This situation is commonly found in townships, informal settlements and rural areas. The 2011 national census revealed that only 60.2% of households in the municipality have access to water inside their dwellings.

6.3. Literature Review

Few studies that use choice experiments (CE) to value water resources have been done in South Africa. The available literature is on the water rights preferences of small irrigators (see Speelman and Veettil, 2013; Saldías et al., 2016), willingness to pay (WTP) for recreational fishing (see Lee, Hosking and Du Preez, 2014), and water values in different use sectors (see Nieuwoudt and Backeberg, 2011). Studies that actually estimate household preferences for water service attributes are more scarce. The few available studies were conducted in rural parts of South Africa (see Kanyoka, Farolfi and Morardet, 2008), middle-income urban areas (see Snowball, Willis and Jeurissen, 2008), and informal settlements (see Goldblatt, 1999). This section reviews some of the literature using CE to elicit household water preferences. Literature from both South Africa and various other developing economies is reviewed.

Brouwer, Job, Kroon and Johnston (2015) use CE to compare rural and urban WTP for improved drinking-water quality in Kenya. More precisely, the study examines the value attached to the characteristics of a new gravity-driven membrane (GDM) drinking-water filter, before its marketing in urban and rural areas of Kenya. A sample of 150 urban and 150 rural respondents was used. Respondents were asked to choose between two different in-house GDM filters. Attributes relating to these filters were: flow rate, drinking-water storage capacity, effectiveness in reducing the prevalence of diarrhoea in children, and price. The mixed logit model (MLM) was used to analyse respondents' choices. Before controlling for income, results indicated WTP values that were higher for the urban sample than for the rural sample. The filter's effect on children with diarrhoea was among the most important determinants of choice and WTP in both urban and rural areas. Rural households were found to be more price-sensitive, and willing to pay more in relative terms. When marketing the filter across urban and rural areas, a differentiated marketing strategy was recommended.

Vasquez, Franceschi and Van Hecken (2011) used CE to investigate households' preferences for improved water services and decentralisation levels in urban Matiguas in Nacaragua. A total of 1 015 households connected to the water system were surveyed. Respondents chose between the existing national water provider and receiving water from the municipality. Choices were made based on attributes affecting decentralisation outcomes. These attributes were: the service quality that the institutions would provide; institutions' knowledge of water problems in the city; the institutions' capacity to solve the problems identified; the institutions' interest in solving the problems; and the amount of resources that would be invested in the water system. Choices made by respondents between these institutions were treated as a clear indication of households' preferences for levels of decentralisation, and showed potential impediments to the expected outcomes of decentralisation. Results revealed that households preferred the existing departmental administration to municipal water service provision, but believed that the municipality would be more interested in improving service delivery. It was revealed that households were willing to pay an increment of at least 112% above their current monthly water bill for reliable and safe drinking water services, regardless of administration type (Vasquez, Franceschi and Van Hecken, 2011).

Snowball, Willis and Jeurissen (2008) used CE to elicit the WTP for water service improvements for 71 households in Grahamstown West, a middle-income urban area in South Africa. Attributes used in the experiment were bacteria count, discolouration, water pressure, supply interruption, water meter problems, and price. The conditional logit model (CLM) was used to analyse the choice results. Results revealed that bacteria count, discolouration, supply interruptions and price were statistically significant determinants of choice.

Limitations encountered in the study of Snowball et al. (2008) include sample bias and the use of a small sample size. Although small CE samples can produce a large number of observations because each respondent makes multiple choices, a sample of only 71 households may be considered too small for the making of robust policy recommendations. The current study avoids these limitations by including a larger sample size that covers all the possible income groups.

Kanyoka, Farolfi and Morardet (2008) used CE to elicit household preferences and WTP for multiple-use water services in South African rural areas. The study was conducted in seven villages in Sekororo-Letsoalo in the Limpopo Province, where 169 households were interviewed. Households were divided into those without taps in the dwelling or in the yard, and those with private taps. Six attributes were presented to households: water quantity, water supply frequency, water quality, price, productive uses, and source of water. However, source of water was removed from the attributes presented to those with private taps. The CLM was used to analyse and interpret the data. Among other findings, it was revealed that distance, reliability and water quality were more important than the quantity of water delivered. Households using standpipes, rivers or boreholes considered having a private tap as the most important improvement to water services.

In a study that did not use CE but is still important in informing water policy, Nleya (2008) analysed how the provision of water services, as a component of urban development policy, addresses poverty in South Africa. The argument put forward in the study is that there is a direct link between the standard of water services and poverty. It was noted in the study that South Africa has a legacy of spatially differentiated and segregated urban areas, where grinding poverty and opulence exist next to each other. Human livelihoods are inversely affected by a number of factors, including lack of adequate water services, collecting water from distant sources, and higher water prices charged by water service providers. Since water is considered both an economic and a social good, managing it in a way that achieves efficiency and equitability and encourages conservation is a huge challenge. Nleya (2008) concluded that there is a need to develop pro-poor water policies, so as to reach under-serviced sectors of the population. Policies recommended included targeting household assets, such as checking the value of the house to determine if the particular household can afford rates. This is in line with the eThekwini municipality's Free Basic Water Policy, which targets the property value of a household.

Hensher, Shore and Train (2005) used CE to investigate household WTP for drinking water and wastewater service attributes in Canberra, Australia. Choice experiments were mailed to respondents, and 211 responses were obtained. Respondents were presented with two sets of experiments – one on drinking water services, and the other on wastewater services. Attributes for the drinking water services experiment were: frequency of service interruptions; average duration of interruptions; time of day that the water service is interrupted; notification of the interruption; information service provided during an interruption; and price. For the wastewater services experiment, the attributes were: frequency of disruption to the wastewater service; coverage of the disruption; average duration of disruption; information service provided in the event of an overflow; and price. The mixed logit model was used to analyse responses, and results showed reliability of water and wastewater services to be important to households. The frequency and length of disruptions were also important, and households were willing to pay to reduce the frequency and the duration of water service interruptions and wastewater overflows because of hygiene, which they perceived as a high priority (Hensher, Shore and Train, 2005).

Anand (2001) used CE to examine consumer preferences for water supply in Chennai, India, where 148 respondents took part in the experiment. The attributes used were: yard tap or shared tap; quantity and quality; supplied by public sector or private sector; and a monthly charge. The sample area was divided into Chennai city residents, and those from the Chennai metropolitan area. The multinomial logit (MNL) model was used to analyse responses, and the results revealed that access to a yard tap is considered a more important attribute than water quantity, water quality, or the provider. The marginal willingness to pay (MWTP) for having a yard tap was found to be substantially higher than the households' current water expenditure. Most households living in the peri-urban areas were found to be unwilling to pay for water supply improvements. The major reasons for this reluctance were a lack of trust in the public utility and clear indications of equity politics in India, where peri-urban households believe they are entitled to subsidised water.

Except for the work of Nleya (2008), the studies reviewed in this section used choice experiments to elicit household preferences for water service improvements. There are few studies on the use of choice experiments in relation to water in developing countries, including South Africa. There is, however, a relatively significant body of literature that used stated preferences to value water services in emerging countries, where the researchers used the contingent valuation method (CVM).

Studies using CVM include Twerefou et al. (2015) in Ghana, Wang et al. (2010) in China, and Vasquez et al. (2009) in Mexico. There is an urgent need to elicit consumer preferences for water service packages in developing countries. This will not only help satisfy consumer needs; it could be instrumental in water conservation and raising revenue for water utilities. Water conservation is imperative in South Africa because the country is water scarce. Understanding consumer preferences, and subsequently providing the preferred water service packages, could ease the cash-flow problems experienced by water-providing municipalities. The following section gives a brief narration of the theoretical framework underpinning choice experiments.

6.4. Choice Experiments – Theoretical Framework

To elicit households' preferences for water services packages in the eThekwini metropolitan municipality, the study uses choice experiments (CE). CEs are stated preference (SP) surveys that give respondents a series of alternatives, differing in attributes and levels (Hanley, Mourato and Wright, 2001). Respondents compare the available alternatives, and choose the one that maximises their utility. The CE method is suitable when the researcher intends to establish the value of individual attributes of an environmental good (Anand, 2001). By presenting respondents with a hypothetical setting and asking them to choose their preferred alternatives, CE clarifies the attributes that determine the value people place on non-market goods (Vloerbergh et al., 2007).

McFadden (1973) explains that the theoretical foundations of CE are coined from the random utility theory, which hypothesises that an individual makes choices based on the characteristics of the good, along with a random component. The random component could emerge from the uniqueness embodied in the individual's preferences, or due to the researcher having incomplete information about the individual observed (Ben-Akiva and Lerman, 1985). Given this, the random utility theory hypothesises that the utility U_{ij} of individual i obtained from alternative j is not known, but can be decomposed into a deterministic component V_{ij} and an unobserved random component, ε_{ij}. Therefore, the individual utility function will be presented as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (9)$$

Alternatively, the utility function in Equation 9 could be expressed by decomposing the indirect utility function for each individual U_{ij} into two components. These are the deterministic component (V) normally specified as a linear index of the attributes (X) of the j^{th} alternative in a choice-set, and a stochastic component (e) representing the error term. Therefore, the function assumes the form:

$$U_{ij} = V_{ij}(X_{ij}) + e_{ij} = \mathrm{b}X_{ij} + e_{ij} \qquad (10)$$

The equation above shows that socio-economic variables can be included together with the attributes of each choice-set. However, because socio-economic variables remain the same for choice-sets of a particular individual, Hanley et al. (2001) suggest that they should be entered as interaction terms or by way of splitting the dataset. Any rational individual i would be assumed to choose alternative j over alternative k if $U_{ij} > U_{ik}$. The deterministic component V_{ij} can be assumed to be a linear function of the explanatory variables, $V_{ij} = \boldsymbol{x}'_{ij}\boldsymbol{\beta}$. In this case β is a vector of coefficients associated with the vector x' of the explanatory variables, which are attributes of alternative j of individual i (Greene, 2000).

Discrete choice theory suggests that the assumptions placed on the random component of the utility determine the statistical model to be used. The statistical models that can be used to analyse choice experiment responses are the conditional logit model (CLM), multinomial logit (MNL) model, random utility model (RUM), mixed logit model (MLM), and the latent class model (LCM). Since attributes are used as explanatory variables in estimation, the MNL model gives clear estimates of attributes that are most preferred by respondents. Therefore, we have chosen the MNL model. The model assumes that the random components (error terms) are independently and identically distributed with an extreme value type I distribution, the variance of which is:

$$var(\varepsilon) = \pi^2\tau^2/6 \tag{11}$$

In this context, τ is a scale parameter used to normalise the model. Therefore, the choice probability of an alternative in the MNL is expressed as:

$$P_{ij} = \exp\left(\frac{v_{ij}}{\tau}\right) / \sum_{k=1}^{K} \exp(\frac{v_{ik}}{\tau}) \tag{12}$$

When the MNL is applied to n choice-sets, the probability that individual i will choose alternative j is:

$$P_i(j) = P\left\lfloor x'_{ij}\,\beta + \varepsilon_{ij} \geq max_k \in_{ci} (x'_{ik}\,\beta + \varepsilon_{ik})\right\rfloor = \exp\left(x'_{ij}\,\beta\right) / \sum_k \in_{ci} \exp(x'_{ik}\,\beta) \tag{13}$$

Equation 13 implies that the probability that individual i chooses alternative j is equal to the probability that the utility derived from j is greater than the utility derived from other possible alternatives (Whittington et al., 1990; Katyoka et al., 2008).

The main aim of this kind of analysis is to estimate welfare measures. To be more specific, the intention is to obtain the MWTP (Dikgang and Muchapondwa, 2016). The study also estimates the MWTP of respondents. MWTP is a welfare measure that shows the marginal rate of substitution (MRS) for attributes. More precisely, MWTP gives average estimates of what households are prepared to pay, for or against the improvement of each attribute. Assuming a linear utility function with the cost C component:

$$U_{ij} = \beta a_j + \mu(C_i - p_j) + \varepsilon_{ij} \tag{14}$$

The MRS between an attribute and cost is:

$$MRS = -\frac{\partial U_{ij}/\partial a_j}{\partial U_{ij}/\partial C_i} = -\frac{\beta_j}{\mu} = MWTP \tag{15}$$

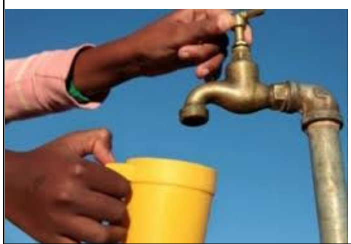
This is a simple ratio of the coefficients which can be compared across models because the scale parameters are cancelled. According to Dikgang and Muchapondwa (2014), the analyst can make use of a set of observed discrete choices to determine different marginal values for each attribute used in explaining the policy alternatives, instead of a single value for the whole policy scenario. The possibility of only getting the latter is considered a constraint of the CVM – which, unlike the CEs, is unable to trace out the underlying WTP for each attribute. Despite having a lot of advantages, choice experiments are not a substitute for other stated preference methods (for example CVM); rather, CEs complement them.

6.5. Research Design

The first step in modelling a choice experiment is selecting relevant attributes and realistic attribute levels (Hanley et al., 2001). When conducting household surveys, Statistics South Africa collects information on how people access water in terms of the main source of water (inside or outside dwelling) and other important aspects. This is because South African water policies have some minimum standards for water provision to households in terms of pressure, distance and quality. It is imperative to investigate which of these attributes are most preferred by households. In this study, a water service package is defined as one that consists of varying levels of five attributes: access to piped water, reliability of water supply, water pressure, water quality, and cost per month.

Two focus groups were established and a series of discussions conducted, to refine the attributes and levels of the experiment. After a thorough consultation of the literature and with insights gathered from the two focus groups, levels were assigned to the chosen attributes. Levels for piped water were deduced from the 2011 national census, which shows that a household in the eThekwini municipality accesses water from inside the dwelling, from the yard, from a community tap, or from other sources. The current domestic water tariff structure published by the eThekwini municipality was used to assign levels to the cost attribute. The water tariff structure has five successive blocks (IBT structure), and the average costs for consumption in each block were used as levels for the cost attribute. Levels for water pressure, reliability and quality were established following some detailed focus group discussions. The water service attributes and levels used in the study are presented in Table 7 below.

Table 7: Attributes and levels used in the study

Attribute	Description	Attribute Levels
Piped water 	Access to piped or tap water in the dwelling, on-site or off-site. This shows how piped water is delivered to households.	**Level 1:** Inside dwelling **Level 2:** In yard **Level 3:** Community tap: less than 200m from dwelling **Level 4:** Community tap: more than 200m from dwelling **Level 5:** No access to piped water
Reliability of supply 	Whether the household had any interruption in piped water supply in the last month.	**Level 1:** Yes **Level 2:** No
Water pressure 	Pressure is the force that pushes water through pipes. Water pressure determines the flow of water from the tap.	**Level 1:** High water pressure **Level 2:** Low water pressure

Attribute	Description	Attribute Levels
Water quality 	A measure of the suitability of water for a particular use, based on selected physical, chemical and biological characterises.	**Level 1:** Safe to drink **Level 2:** Has colour **Level 3:** Has a taste **Level 4:** Has a smell
Cost 	Cost per month.	**Level 1:** R120 **Level 2:** R220 **Level 3:** R400 **Level 4:** R680 **Level 5:** R980

Traditionally, most studies in the literature have used the orthogonal design to populate the hypothetical choice situations shown to respondents (see Willis et al., 2005; Snowball et al., 2008; and Katyoka et al., 2008). Even though orthogonal designs allow for the effects to be estimated independently in linear models, this is no longer true for non-linear models such as discrete choice models (Bliemer and Rose, 2006). Critics of the orthogonal design argue that even though the design may be orthogonal, often the data used in estimation is not orthogonal, as a result of many things that go wrong when researchers attempt to maintain orthogonality in stated choice data (see Bliemer, Rose and Chorus, 2015).

In recent years, researchers have been using efficient designs. The problem with efficient designs is that they are only efficient if the prior parameters are correct. If these parameters are wrong, an efficient design can become inefficient (Bliemer and Rose, 2011). Studies suggest that Bayesian D-efficient designs are more robust, because their efficiency is less sensitive to mis-specification of the priors (Bliemer et al., 2008).

In this study, the Bayesian D-efficient design is used to create the hypothetical choice-sets presented to households. The problem of prior parameters associated with efficient designs does not exist in a Bayesian efficient design, because the latter assumes random distributions of prior parameters. Six choice-sets with two alternatives were designed. The number of draws for Bayesian priors was determined by five Gaussian draws. According to Bliemer et al. (2008), using the Bayesian approach, the efficiency of a design is evaluated over numerous different draws taken from the prior parameter distributions assumed in generating the design. The Gaussian method is argued to be the best approximation method when calculating the Bayesian efficiency of choice-sets.

A number of choice experiment studies in literature impose the same status quo on respondents (see Snowball et al., 2008; Poirier and Fleuret, 2010; Vasquez et al., 2011; Gelo and Koch, 2012; Bhaduri and Kloos, 2013; Dikgang and Muchapondwa, 2014; Dikgang and Muchapondwa, 2016). South African cities typically consist of suburban and township areas. The former are higher-income areas, while the latter are low-income areas; therefore, the samples in these two areas are distinct, implying different status quos. Consequently, this study stratifies the sample into two strata – one for suburban households, and the other for township households.

In the context of this study, 'township households' refers to all non-suburban households in the municipality: households in townships, informal settlements, and rural areas. These groups of households have been grouped together under 'townships' because in most cases, the water service packages they receive are similar. Two distinct questionnaires were developed, one for each stratum, with each having a status quo applicable to the specific stratum. An example of a choice-set presented to respondents is given in Table 8 below.

Table 8: Example of a typical choice-set presented to respondents

	STATUS QUO	ALTERNATIVE 1	ALTERNATIVE 2	NONE
Piped water	In yard	In yard	Inside dwelling	
Reliability of water supply	No	Yes	No	
Water pressure	Low pressure	Low pressure	High pressure	
Water quality	Safe to drink	Has colour	Has a smell	
Cost per month	R0	R120	R680	
I WOULD CHOOSE:	☐	☐	☐	☐

Table 8 above shows an example of one of the choice-sets presented to township households. Respondents were given six choice-sets, followed by general socio-economic questions. In each choice-set, respondents were asked to choose between alternatives 1 and 2, or to opt out by choosing the status quo. Where respondents preferred neither of the alternatives nor the status quo, they could choose ‘none’. Enumerators would go through the electronic questionnaire with the respondent, and during the process the respondents would choose their most preferred options. Captured data were stored electronically (using the ONA server), immediately after each interview, and retrieved later for cleaning and analysis. To avoid sample selection bias, respondents were randomly selected from across the municipality.

6.6. The Survey

The survey was undertaken by the Nelson Mandela Metropolitan University and University of Johannesburg research team, in the eThekwini metropolitan municipality, during the period September to November 2016. Four trained enumerators fluent in both English and isiZulu were employed to collect data. A total of 1002 respondents (500 from townships and 502 from suburbs) were interviewed.

As alluded to earlier in the study area section, the survey took place in several locations around the eThekiwni metropolitan municipality. Township households surveyed were from Inanda, Ntuzuma, Phoenix, Verulam, Westville, Chesterville, Chatsworth, Umlazi, Bhambayi and Umbumbulu. Suburban households surveyed were from Morningside, Musgrave, Overport, La Lucia, Umhlanga, Verulam (it does not necessarily correspond to a specific legal township or suburb, hence it appears in both lists) and New Germany. While township respondents were easy to access, very welcoming and keen to respond to questions, the reception was not the same in the suburban stratum.

Generally, researchers struggled to access suburban households; in most cases, the occupants would be at work, or have tight security barriers around their homes, or were simply not interested. To solve this problem, this study resorted to visiting areas where such householders spend their leisure time, for example parks, shopping malls, beaches and other places such as car washes. As a measure to avoid interviewing non-suburban residents, respondents were asked their place of residence before each interview. The enumerators also took cognisance of the possibility of surveying the same household more than once. To avoid this possibility, respondents were asked if they were aware of any member of their family having taken part in any water service survey in the recent past. The descriptive statistics of the surveyed sample are presented in Table 10 below.

Table 9: Averages of the raw choice experiment surveys

		Townships	**Suburbs**
Number of respondents		500	502
Gender	Female	72%	41%
	Male	28%	59%
Household head	Yes	53%	42%
	No	47%	58%
Household size	Minimum	1	1
	Mean	5	4
	Maximum	20	15
Marital status	Single	67%	49%
	Married	31%	48%
	Other	2%	3%
Race	African	81%	42%
	Indian	16%	44%
	Coloured	2%	5%
	White	1%	9%
Age	16-24 years	18%	13%
	25-34 years	24%	34%
	35-44 years	21%	25%
	45-54 years	15%	14%
	55-64 years	11%	9%
	65+ years	11%	5%
Education	Never attended school	6%	1%
	Primary	11%	1%
	High school	62%	24%
	Certificate	11%	21%
	Diploma	7%	27%
	Degree	3%	23%
	Postgraduate	-	3%
	Other	-	1%

As anticipated, the majority of the respondents in the township sample were female. In townships, it is typical to find women at home during the day. The average household size for the two samples is almost the same. Africans were dominant in townships, while Indians dominate the suburb sample slightly. This is consistent with the actual dynamics in the municipality and in most South African cities, where township dwellers are mostly Africans. In both samples, the majority of the respondents were in the 25-44 age group. Those with a high school education formed the bulk of the township respondents. Unlike in the townships, where quite a significant number of respondents either had only primary school education or had never attended school at all, most suburban respondents had a minimum of a high school education. To further understand the socio-economic characteristics of the respondents, information was requested on their income, source of income, and whether they receive free basic water. Respondents were also asked about how they access potable water, their experiences of water supply interruptions, and the quality of the potable water they receive. Table 10 below presents the statistics for these socio-economic characteristics.

Table 10 below shows that the majority of township respondents earn below R2 500 per month. The income statistics are completely different in the suburban sample, where the majority of the respondents earn up to R15 000 monthly, and quite a number of respondents earn between R15 000 and R30 000 per month. Income statistics are essential because they show the ability of households to pay for water services. Township respondents receive income mainly from salaries, pensions, and government grants. Other sources of income in the township sample include informal trading, where households are involved in small businesses as vendors.

In the suburban sample, salaries and wages form the main source of income for most of the respondents. Up to 64% of the township respondents receive free basic water services, which suggests that most properties in townships are valued at less than R250 000. Even though the majority of the township respondents access potable water inside their dwellings, 22% of them access water from the yard and 4% get water from community taps. These dynamics do not exist in the suburbs, where all the respondents access potable water inside their dwellings.

Table 10: Other important socio-economic statistics

		Townships	Suburbs
Income per month	<R2500	71%	
	R2500 < R5000	16%	
	R5000 < R10000	10%	
	>R10000	3%	
	< R15000		49%
	R15000 < R30000		30%
	R30000 < R50000		13%
	>R50000		8%
Source of income	Salary/wages	34%	72%
	Government grants	27%	1%
	Pension	23%	6%
	Investments	0.2%	17%
	Hand-outs	3%	2%
	Other sources	12%	2%
Receive free basic water	Yes	64%	-
	No	36%	-
Access to portable water	Inside dwelling	74%	100%
	In yard	22%	0
	Community tap	4%	0
Water supply interruptions	Very often	65%	7%
	Once in a while	23%	52%
	Not at all	12%	41%
Water quality	Not clear	32%	29%
	Bad taste	1%	3%
	Bad smell	0	1%
	Has colour	2%	9%
	Good quality	65%	57%

The majority of township respondents indicated that they experience water supply interruptions very often; this is different in the suburban sample, where most of the respondents suggested that they experience water interruptions only once in a while. In terms of the quality of potable water received, respondents from both samples indicated that they receive water of good quality. However, a considerable number of respondents from both samples revealed that the potable water they receive is not clear. In a nutshell, these statistics are essential in shedding some light on the characteristics and experiences of the respondents, which in turn are likely to determine their choice of water service package in choice experiments.

Additionally, respondents were asked to indicate the attribute that influenced their decisions the most when making choices. The most influential attributes were elicited for both strata. Figure 13 below shows the frequency distribution of the attributes influencing household choices. The values presented in the figure are expressed as a percentage of the respondents.

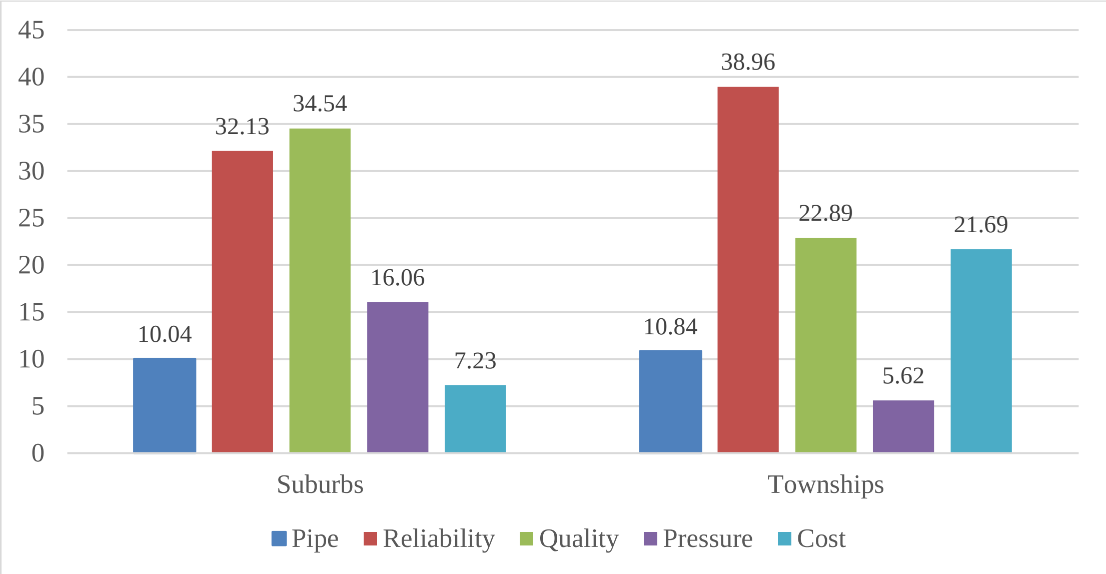


Figure 13: Frequency distribution of attributes influencing choices

In the suburban stratum, water quality is the dominant influential attribute, followed by water supply reliability. In the township stratum, the same two attributes are the most important; however, water supply reliability is more dominant than water quality. The monthly cost of water services also has a relatively greater influence in the township stratum. Water pressure is the least influential attribute in the township stratum. These results show that the majority of suburban households are mostly concerned with water quality and reliability, compared to how they access piped water, water pressure, and cost. On the other hand, township households are more concerned with water supply reliability, quality, and cost, compared to water pressure and how they access piped water services. An econometric analysis of the data will give a more detailed understanding of households' preferences for water service attributes. The subsequent section presents and discusses the results from the econometric analysis.

6.7. Results and Discussion

The MNL (multinomial logit) model was used to estimate the value that households place on each attribute presented in the choice experiment. In its simplistic nature, MNL captures the taste variations of respondents, while their unobserved heterogeneity is captured via the error term, in a simple fashion. MNL fits a conditional logistic regression model for matched case-control data. The model can compute robust and cluster-robust standard errors and adjust results for complex survey designs. In this study, consumer choices are estimated as a function of five water services attributes (cost, pipe, reliability, pressure and quality). Subsequent to that, choices are also estimated as a function of the various attribute levels.

Analysis is performed in three steps. First, the results showing consumer preferences for water service attributes are presented. Second, the results showing household preferences for the attribute levels are presented. This is done in order to give clearer insight as to the preferences suggested in the first step. Finally, the WTP figures for each attribute in each stratum are presented. In discussing the results, we compare the strata both in each block and across blocks. Table 11 below shows the estimation results for consumer preferences for water service attributes, for both the suburban and the township strata.

Table 11: Results – household preferences for water service attributes

	Suburb		Township	
COST	0.002**	(0.001)	-0.001***	(0.0004)
PIPE	-0.740***	(0.164)	-0.327***	(0.054)
RELIABILITY	0.264	(0.286)	-0.026	(0.135)
PRESSURE	0.242	(0.579)	-0.041	(0.238)
QUALITY	-0.492**	(0.232)	-0.500***	(0.089)
Intercept	1.043 (0.869)		2.135*** (0.604)	
LL	**-1210.2**		**-1661.5**	
AIC	**2436.4**		**3339.1**	
BIC	**2478.8**		**3381.5**	
N	**1485**		**1490**	

Note: ***, ** and * = significance at 1%, 5%, 10% level, respectively.
Standard errors are in parenthesis.

The results in Table 11 are interpreted according to the sign and significance of the coefficients. A negative and significant coefficient suggests that changes in the attribute reduce the likelihood that the alternative will be chosen; whereas a positive coefficient indicates that changes in the attribute increase the likelihood that the alternative will be chosen. In other words, negative coefficients mean households do not prefer changes for the particular attribute, while positive coefficients indicate that households do prefer changes. Meyerhoff and Liebe (2009) argue that rational choice theory assumes that respondents make choices based on the attributes, and would choose an alternative that maximises their utility – implying that apart from the attributes and their levels, there are no other factors that systematically determine respondents' choices.

In both strata, RELIABILITY and PRESSURE are not statistically significant indicating that these attributes are not important to suburban households. While COST, PIPE and QUALITY are statistically significant, COST has a positive coefficient of 0.002 in the suburban stratum. PIPE and QUALITY have negative coefficients in both suburbs and townships, indicating that households do not prefer any changes in both the way they access piped water and the quality of the water they receive. The positive coefficient of the monthly cost of water services in the suburbs indicates that households do not mind increases in the cost of water services. This result can be true because practically, suburban households are high-income earners, and can afford to pay higher water tariffs.

However, in the township stratum COST has a negative and statistically significant coefficient, suggesting that township households prefer not to have increases in monthly water costs. The township result is consistent with reality, as the majority of township households receive free basic water (as confirmed earlier in Table 10). In the literature, most studies find a negative cost coefficient (see Hensher et al., 2005; Vasquez et al., 2011; Gelo and Koch, 2012; Brouwer et al., 2015; Dikgang and Muchapondwa, 2014 & 2016). The discrepancies in the sign of the cost attribute between the suburban and township households explains the findings in the South African water supply literature that the demand for water is more inelastic for higher-income groups than for lower-income groups (see Vuuren et al., 2004; Bailey and Buckley, 2005; Jansen and Schulz, 2006).

How households access potable water (PIPE) is important to both suburban and township households. Earlier studies by Kanyoka et al. (2008), in rural South Africa, and Anand (2001), in India reveal that distance and access to a yard tap are more important attributes in household preferences for water services. The negative coefficient for PIPE shown in this study indicates that households in both strata would prefer no changes in the way they access piped water services. Several households from both suburbs and townships access water either inside the dwelling or from the yard. Given their situation, they are reluctant to accept any changes in access to potable water. Households are likely to consider levels of access such as community taps or the lack of piped water as regressive.

Furthermore, results show that water supply reliability (RELIABILITY) is not important to both suburban and township households. This result is not consistent with Snowball et al. (2008) and Hensher et al. (2005) who found water supply reliability to be important in South Africa and Australia respectively. However, the revelation that water pressure (PRESSURE) is an important attribute to households is consistent with findings from Snowball et al. (2008) where water pressure is revealed not to be important to residents in Grahamstown.

QUALITY has significant and negative coefficients for both suburban and township households, suggesting that even though quality is important to households in both strata, they would prefer no changes in the current water quality. This result is consistent with the descriptive statistics in Table 10 above, where the majority of households from both strata indicated that the potable water they receive is of good quality. Generally, the eThekwini municipality is one of the best in South Africa for water quality in terms of chemical and physical characteristics, and has won top awards based on the Blue Drop benchmarking initiative. In the literature, water quality is consistently important to households. The importance of water quality to households across all income levels is confirmed in Kanyoka et al. (2008); Snowball et al. (2008) and Vasquez et al. (2011).

The results presented in Table 11 above show households' overall preferences for each attribute. In an attempt to understand how the levels in each attribute influenced choices, we have estimated households' preferences for each level in every attribute. An analysis of levels shows which components of the attribute are preferred or not preferred by households. This is good for policymakers, meaning they would know the specific aspects of attributes to include and exclude in a water service package. The MNL model was used to estimate households' preferences for water service levels, and the results are presented in Table 12 below.

Table 12: Results – household preferences for levels in each attribute

Attribute	Level	Suburbs	Townships
Access to piped water	Inside dwelling	-17.07713 (5082.553)	0.13313 (0.41707)
	In yard	-17.10568 (5082.553)	0.91844*** (0.39450)
	Community tap <200m	-20.37896 (5082.553)	-0.51122 (0.53275)
	Community tap >200m	-18.00228 (5082.553)	-2.07548*** (0.58682)
	No piped water	-20.57067 (5082.553)	-0.51007 (0.33817)
Reliability	Reliable supply	11.80909 (5082.553)	-0.71330 (0.64058)
	Unreliable supply	13.4897 (5082.553)	-1.68369*** (0.64509)
Pressure	High pressure	2.35507*** (0.19784)	-0.16451 (0.20697)
	Low pressure	0	0
Water quality	Safe to drink	2.54535*** (1.10962)	1.05422*** (0.43105)
	Has colour	-1.22527 (1.16688)	-0.05695 (0.37882)
	Has taste	0.67446 (1.03198)	0.27750 (0.49829)
	Has smell	0	0
LL		-1864.533	-2472.506
N		5976	5974
$\boldsymbol{p^2}$		0.36	0.17

Note: ***, ** and * = significance at 1%, 5%, 10% level, respectively.
Standard errors are in parenthesis.

Table 12 above shows that high water pressure and water that is safe to drink are the only important levels to suburban households. The positive signs on the coefficients of these two levels suggest that suburban households prefer the existing levels. On the other hand, township households prefer accessing piped water services at least in the yard, and do not prefer accessing water from a community tap located more than 200 metres away from their place of residence. Additionally, township households prefer water that is safe to drink and do not prefer an unreliable water supply. These preferences are both consistent with prior expectations that households would prefer reliable and high-pressure water that is safe to drink. The implication of this is that the municipality should focus resources on providing high-pressure water that is safe to drink in the suburbs; whereas in townships, water that is reliable and safe to drink should be provided at least in the yard.

The study also estimates the MWTP, which is a welfare measure showing the average estimates of what households are prepared to pay for or against changes in each attribute. Positive and significant coefficients show the average amount that households are willing to pay for changes in a particular attribute, whereas negative and significant coefficients show how much households are willing to accept as compensation for changes in the attribute. Table 13 below shows the MWTP for both suburban and township households.

Table 13: Marginal Willingness to Pay for water services attributes

	Suburb	**Township**
Pipe	453.41**	-313.96***
	(230.65)	(116.02)
Reliability	-162.01	-24.54
	(182.67)	(129.55)
Pressure	-148.14	-39.01
	(292.06)	(216.20)
Quality	301.67*	-479.83***
	(106.37)	(143.74)
Wald Statistic	**21.51**	**30.15**
Prob. from Chi^2	**0.000**	**0.000**

Note: ***, ** and * = significance at 1%, 5%, 10% level, respectively.
Standard errors are in parenthesis.

The figures presented in Table 13 above are monetary values. Positive figures suggest what households are willing to pay, while negative figures show what households are willing to accept as compensation for changes in the attribute. The MWTP estimates are once-off amounts households would have to pay for their preferred attributes. As expected, MWTP figures for suburban households are significantly higher than those for township households, which is consistent with the income levels of the two samples.

In the suburbs stratum, PIPE and QUALITY are the only attributes with positive and statistically significant MWTP figures. The positive coefficient of PIPE in suburbs indicates that suburban households are willing to pay R453.41 to continue accessing water from inside the dwelling. Furthermore, households from suburbs are willing to pay R301.67 to continue with the current water quality. However, even though only PIPE and QUALITY have statistically significant MWTP figures, the negative signs on the MWTP estimates indicate that township residents are not willing to pay for any of the water services attributes. Rather they are willing to accept R313.96 as compensation for changes in how they access piped water and R510.46 for changes in quality. Generally, township results are an indication that households are satisfied with their current water service packages and prefer compensation should there be changes in the water service attributes

Based on the MWTP estimates, it can be suggested that if the municipality wants to raise more revenue from water services, it should invest more in how households access piped water and water quality in the suburbs.

6.8. Conclusion

This study examined households' preferences for water service attributes in the eThekwini metropolitan municipality. Choice experiments were used to elicit households' preferences for water service packages. A water service package was defined as consisting of varying levels of five attributes: position of piped water, reliability of water supply, water pressure, water quality, and monthly cost. A sample of 1002 households was stratified into suburban and township households, and questionnaires offering different status quos were presented to each stratum.

In the context of this study, 'township households' refers to all non-suburban households in the municipality: households from townships, informal settlements, and rural areas. The choice experiments presented to each stratum had a status quo applicable to the particular stratum. Estimation and analysis of results was performed using MLM. Firstly, the study presented household preferences for water service attributes. Secondly, results on the preferred levels for each attribute were presented; and finally, the MWTP (marginal willingness to pay) figures for the water services attributes were estimated.

The estimation results reveal that while households from the suburbs do not mind increases in the monthly cost of water services, township households do not prefer any increases in monthly water costs. We also found that households in both strata would prefer no changes in the way they access piped water services. This suggests that households in the municipality are satisfied with the way they access potable water services. The results also showed that reliability of water supply and water pressure are not important attributes to households in both strata. Subsequently, it was shown that both suburban and township households in the two strata would prefer no changes in the current water quality, signifying their contentment with the current quality of water received.

An analysis of households' preferences for attribute levels was conducted separately, and results showed that high water pressure and water that is safe to drink are the only important levels to suburban households. In the townships, households prefer accessing piped water services at least in the yard and do not prefer accessing water from a community tap located more than 200 metres away from their place of residence.

Additionally, township households also prefer water that is safe to drink and do not prefer any changes in how they access piped water. The households' MWTP for water service attributes was also estimated; the results were that estimates for suburban households are higher than those for township households. Another finding was that suburban households are willing to pay more for water quality and how they access piped water, while township households are not willing to pay for any water service attribute but would rather expect compensation should there be changes in the way they receive water services.

Finally, the revelation that both suburban and township households would prefer no changes in the current water quality suggests that the municipality is satisfying demand as far as this attribute is concerned, and should maintain the good standard of providing good quality water to its residents.

CHAPTER 7: CHOICE EXPERIMENTS CONCLUSION AND RECOMMENDATIONS

7.1. Significance of the Findings for Municipalities

In addition to benchmarking, water utilities also require a source of comprehensive, reliable data as a basis for meeting their constituents' demands for high-quality public services. There are gaps regarding whether water service packages meet consumer demand. We make use of CE to elicit households' preferences for water service packages in the eThekwini metropolitan municipality. A 'water service package' is defined as consisting of varying levels of five attributes: position of piped water, reliability of supply, pressure, quality, and monthly cost.

Unlike in most CE studies where the same status quo is assigned to a visibly diverse sample, this study stratified the sample into suburbs and townships. The MNL model was used to estimate water service preferences for households in each stratum. Furthermore, unlike in most CE studies where only the preferred attributes are estimated, our study goes further, to estimate household preferences for the levels that make up the attributes. Furthermore, the households' MWTP was also estimated.

Among other findings, analysis of the CE data revealed that both suburban and township households do not prefer any changes in the way they access piped water or to the quality of the water they receive. Additionally, while township households do not prefer changes in the cost of water services, households from suburbs do not mind changes in the cost of water services. The households' MWTP for water service attributes was also estimated, and the results showed that estimates for suburban households are higher than those for township households; also that suburban households are willing to pay more for water quality and pipe, while township households are not willing to pay for changes in any of the attributes.

The information generated by this study on water service package preferences is useful, as it enables total household water requirements to be determined more accurately.

With this information, water service authorities should have a better idea of how to structure their water service packages.

7.2. Recommendations

Based on the findings reported in this study, we make the following recommendations:

- In suburban areas, if there are budget constraints, the municipality should increase tariffs to ensure water is safe to drink, and ensure access to water inside dwellings. Results for the suburban stratum revealed that cost is not an important attribute, as long as it results in improvements in the other attributes mentioned above.
- Since both suburban and township households are satisfied with their current quality of water, no further investment should be made towards further improvement of water quality. Instead, for both strata, resources should be channelled towards improvement in other areas that require it.
- The most immediate need is to bring about water infrastructure within yards in township areas. Currently, some township households rely on community taps within 200 metres of their yard, while some taps are even more than 200 metres away. Other households have taps inside their yards, while others have taps inside their dwellings. The results suggests that taps within yards should be prioritised over community taps and those inside dwellings.

7.3. Future Research

There is a gap in the South African literature on studies that use CE to elicit how well South African water service packages meet demand. Our study examined household preferences in only one municipality. There is a need for practitioners, academics and researchers to examine whether water service packages in the rest of South Africa satisfy household demand. The census and other surveys carried out in South Africa, including by Statistics South Africa, should expand the scope of their questionnaires to include preference questions on water and sanitation services.

Most importantly, it is vital that municipalities undertake choice experiment surveys in order to better understand household preferences for water and sanitation services, and to ensure that what they provide is in line with household demands.

Furthermore, the current study examined only household consumers. There is a need for research into other water consumers, such as farmers, manufacturing businesses and others. Research in such areas is essential, because South Africa is a water-scarce country, and sustainable solutions should be developed to sustain both its limited water resources, and its industries that are water-intensive.

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Appendix 1: NEW WATER SERVICE AUTHORITY DATA

Table A1: Data for 147 municipalities that are water service authorities (2013)

Mun code	Municipality	Mun. Category	Total operating expenditure	Number of water consumer units	Units receiving free basic water	Average bulk water tariff (R/kl)	Price of labour	Price of capital	Authorised Consumption (Q - kl/annum)	Population served (No.)	Length of mains (km)	Total connections (metered and unmetered)	Free Basic Services Policy	Number of water sector employees	Bulk purchases
NC082	!Kai! Garib	B3	16831000	9469	3825	7.17	162240		3151258	66299	151	8089	Self-targeting	50	2564000
NC084	!Kheis	B3	990000	2417	2293	7.17	26938	88	607051	16743	65	2306	Self-targeting	16	326000
NC083	//Khara Hais	B2	24645000	20256	11838	7.17	71165	58	11240340	94100	66	3282	Self-targeting	121	1553000
KZN263	Abaqulusi	B3	45146000	19278	1193	4.70	72907	55					Self-targeting	151	71000
MP301	Albert Luthuli	B4	40775000	49973	33612	5.52	149750						Broadbased targeting	132	2000
DC44	Alfred Nzo	C	108289000	75507	74557	7.55				804381			Broadbased targeting	119	3053000
DC25	Amajuba	C	96516000	26970	2252	4.70	894154	67	21386180	503603	684	47910	N/A	13	7000000
DC12	Amathole	C	558299000	244578	118254	7.55	156672	145	12064468	896015	1490	51412	Geographical targeting	850	49484000
EC107	Baviaans	B3	4216000	3794	2290	7.55	140500		625355	17830	86	4231	Consumption-based targeting	10	0
WC053	Beaufort West	B3	1041000	13384	5244	7.00	327833	23	1219929	50274	176	10021	Self-targeting	12	4393000
LIM366	Bela Bela	B3	10790000	14312	2858	4.50	182161						Self-targeting	31	3698000
WC013	Bergrivier	B3	14962000	8407	2239	7.00	134579	20	2153684	62765	316	15785	Self-targeting	19	4768000
WC047	Bitou	B3	24386000	14513	3020	7.00	446467	43	2197195	49849	329	9762	Self-targeting	15	161000
EC102	Blue Crane Route	B3	14839000	7204	4045	7.55	128696	22	2548500	36140	222	11104	Self-targeting	23	1352000
WC025	Breede Valley	B2	45456000	29218	7061	7.00	153042	33	12314966	169161	537	26838	Self-targeting	71	1352000
BUF	Buffalo City	A	504929000	234349	43134	7.55	185434	53	39160850	758105	4015	200733	Self-targeting	320	207416000
MP325	Bushbuckridge	B4	162704000	144902	57641	5.52	343607						Broadbased targeting	107	96600000
EC101	Camdeboo	B3	11945000	10781	8575	7.55	77893	54	3581500	51188	228	11379	Self-targeting	28	0
WC033	Cape Agulhas	B3	11363000	9420	9242	7.00	128682	11	1842079	33498	229	8017	Broadbased targeting	44	620000
DC35	Capricorn	C	204771000	118958	85000	4.50	63264	47	19374833	1272259	1494	141966	Self-targeting	246	33397000
WC012	Cederberg	B3	4638000	8407	1784	7.00	260238	18	1910913	50468	266	13275	Self-targeting	21	547000

Mun code	Municipality	Mun. Category	Total operating expenditure	Number of water consumer units	Units receiving free basic water	Average bulk water tariff (R/kl)	Price of labour	Price of capital	Authorised Consumption (Q - kl/annum)	Population served (No.)	Length of mains (km)	Total connections (metered and unmetered)	Free Basic Services Policy	Number of water sector employees	Bulk purchases
DC13	Chris Hani	C	195477000	53546	27096	7.60	201149		4428341	65812	354	17849	N/A	148	11454000
CPT	City of Cape Town	A	3775909000	779398	288703	7.00	197772	13	265427448	3872545	10867	652497	Broadbased targeting	3422	284340000
JHB	City of Johannesburg	A	5383412000	963886	223431	5.52	301946	7	352151845	4503573	11526	713143	Self-targeting	1543	3249631000
NW403	City of Matlosana	B1	120340000	162335	44569	5.52	149991	17					Self-targeting	114	147746000
TSH	City of Tshwane	A	2544830000	750937	110000	5.52	280596	17	240902105	2966776	10757	472268	Self-targeting	972	1441062000
KZN282	City of uMhlathuze	B1	354989000	73413	73413	4.70	91829	109	29706777	336984	1589	40010	Broadbased targeting	228	86858000
FS192	Dihlabeng	B2	20978000	31035	3537	4.37	168556		4206435	128899	805	40230	Self-targeting	45	124059000
NC092	Dikgatlong	B3	10700000	10210	2030	7.17	141412		482117	47144	65	3253	Self-targeting	34	4306000
MP306	Dipaleseng	B3	6797000	11343	11151	5.52							Broadbased targeting	11	1146000
NW384	Ditsobotla	B3	27972000	44177	6180	5.52	253744						Self-targeting	43	8699000
MP316	Dr J S Moroka	B4	34506000	61803	1629	5.52	144762		5342903	251843	1259	62953	Self-targeting	143	0
WC023	Drakenstein	B1	74022000	60337	29241	7.00	115875	23	15528628	254780	1123	56164	Broadbased targeting	96	20417000
EKU	Ekurhuleni Metro	A	3064012000	652203	444811	5.52	264029	8	232716271	3227737	11489	517011	Self-targeting	895	1815308000
MP314	Emakhazeni	B2	6841000	11855	11600	5.52	123450						Broadbased targeting	20	0
EC136	Emalahleni (EC)	B4	19362000	14883	8181	7.55	237107			119912			Self-targeting	28	229000
MP312	Emalahleni (MP)	B1	140114000	71760	59750	5.52	161405	22	25428596	398850	1868	93417	Self-targeting	84	87635000
GT421	Emfuleni	B1	527537000	240046	166903	5.52	216647	1	42180349	732846	5234	261703	Geographical targeting	204	473945000
NC073	Emthanjeni	B3	8356000	8398	2726	7.17	139778	10	2365159	42632	274	13700	Self-targeting	9	1383000
ETH	eThekwini Metro	A	3543322000	893573	517274	4.70	176146	47	206297410	3468277	12479	474193	Broadbased targeting	2879	1394278000
NC453	Gamagara	B3	20085000	14791	683	7.17		37	5177803	41889	211	10525	Self-targeting	83	10409000
EC144	Gariep	B3	1439000	4859	5644	7.55	92000		1820620	33805	180	8836	Self-targeting	4	0
NC452	Ga-Segonyana	B3	41248000	19825	6013	7.17	45450	89					Geographical targeting	20	0
WC044	George	B1	103978000	36247	15626	7.00	164628	45	9548061	196382	940	47022	Self-targeting	156	0
MP307	Govan Mbeki	B1	195062000	88881	22523	5.52	311918	196	25834008	297050	1428	71389	Self-targeting	49	155586000
DC47	Greater Sekhukhune	C	254432000	178042	166772	4.50	174383						Geographical targeting	588	96004000
NW394	Greater Taung	B4	934000	2559	596	5.52	185250						Technical targeting	12	109000
NC065	Hantam	B3	5759000	4620	1226	7.17	319750	17	678551	21719	149	7175	Self-targeting	8	88000

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WC042	Hessequa	B3	20334000	15580	4737	7.00	243727	13					Self-targeting	22	3537000
EC103	Ikwezi	B3	2513000	2666	956	7.55	455333	5	350400	10578	60	3021	Self-targeting	3	0
DC29	ILembe	C	233541000	124462	28900	4.70	221308	42	7553082	611379	2824	30810	Self-targeting	221	71454000
EC131	Inxuba Yethemba	B3	205769000	16045	11088	7.55	963928		2914500	65812	354	17849	Self-targeting	83	8128000
DC14	Joe Gqabi	C	155124000	67806	1180	7.55	557214	6	1820620	351102	180	8836	N/A	70	7699000
NC451	Joe Morolong	B4	35689000	24250	21766	7.17	148490						Self-targeting	49	4016000
NC064	Kamiesberg	B3	2655000	3881	1345	7.17	80688						Self-targeting	16	818000
WC041	Kannaland	B3	5384000	5650	1300	7.00	99783	37					Self-targeting	23	509000
NC074	Kareeberg	B3	1064000	2390	1214	7.17	42143						Self-targeting	7	0
NC066	Karoo Hoogland	B3	1378000	2818	2204	7.17	60533		804118	12669	65	2447	Self-targeting	15	0
NC086	Kgatelopele	B3	1488000	3368	1742	7.17	96625	22					Self-targeting	8	0
NW374	Kgetlengrivier	B3	3611000	14882	2922	5.52	123294	2					Self-targeting	17	34000
NC067	Khai-Ma	B3	5302000	2214	1696	7.17	51091	11	678783	12545	46	2323	Self-targeting	22	2358000
WC048	Knysna	B2	45402000	20931	9160	7.00	186544	45	3492784	69622	377	18872	Self-targeting	57	0
FS162	Kopanong	B3	32691000	17880	17880	4.37			1419995	49243	401	20071	Self-targeting	76	7484000
EC108	Kouga	B3	41452000	23997	6401	7.55	41639	40	3819500	98936	524	26219	Self-targeting	230	13370000
EC109	Kou-kamma	B3	9603000	9619	2307	7.55	226000	10	1336435	40819	213	10633	Self-targeting	14	36000
WC051	Laingsburg	B3	1676000	1246	363	7.00	38333	105					Self-targeting	9	0
WC026	Langeberg	B3	39351000	16104	6229	7.00	294886	9	6073591	99094	540	26986	Self-targeting	44	1789000
MP305	Lekwa	B3	15563000	31497	19823	5.52	165621						Broadbased targeting	29	137000
NW396	Lekwa-Teemane	B3	20978000	16406	5793	5.52	108200	41					Technical targeting	20	12830000
LIM362	Lephalale	B3	4459000	28157	2950	4.50	33898	18	5456557	116758	490	28407	Self-targeting	49	703000
GT423	Lesedi	B3	43864000	25287	15672	5.52	113096	7	4876122	101061	304	23400	Self-targeting	52	33416000
FS161	Letsemeng	B3	11395000	10181	9972	4.37	161400	2	774629	38686	278	13888	Self-targeting	20	4790000
EC134	Lukhanji	B2	52241000	52267	9405	7.55	82023			191454			Geographical targeting	88	95000
NW372	Madibeng	B1	160285000	100160	3228	5.52	154460	3					Self-targeting	139	51079000
NW383	Mafikeng	B2	33890000	55500	1632	5.52	298829	1	9465997	294733	967	48336	Self-targeting	35	13394000

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FS205	Mafube	B3	7588000	20732	20732	4.37	212710		1418868	57964	340	16994	Self-targeting	52	4811000
NC093	Magareng	B3	8192000	6771	2339	7.17	148650						Self-targeting	20	3575000
EC104	Makana	B2	42826000	23998	6971	7.55	402077		6151500	80699	484	24196	Self-targeting	26	1354000
FS194	Maluti a Phofung	B3	104196000	118440	33740	4.37							Consumption-based targeting	338	17298000
NW393	Mamusa	B3	4512000	14625	9940	5.52	89286						Self-targeting	14	41000
MAN	Mangaung	A	592535000	173346	14365	4.37		12	50829701	748555	3658	170375	Self-targeting	708	338096000
FS196	Mantsopa	B3	11792000	15170	2339	4.37	178469	56	2949889	51134	131	14888	Self-targeting	32	1173000
NW404	Maquassi Hills	B3	36285000	20355	12831	5.52	159208	76					Broadbased targeting	24	30140000
FS181	Masilonyana	B3	2277000	17548	3800	4.37		2					Self-targeting	264	4064000
FS184	Matjhabeng	B1	209877000	96925	25186	7.17	343333		19736905	407072	1571	94282	Self-targeting	75	145546000
WC011	Matzikama	B3	11930000	10058	2184	7.00	127306	11	2842933	68088	370	18518	Self-targeting	36	4573000
MP322	Mbombela	B1	128457000	210766	185608	5.52	153365	12	18109787	593826	1038	83069	Broadbased targeting	167	9273000
GT484	Merafong City	B2	187604000	98238	4272	5.52	128407		7613536	200581	1392	69578	Self-targeting	123	148473000
FS204	Metsimaholo	B2	131205000	42116	24956	5.52	205486	20	12208916	149332	625	44072	Self-targeting	37	87300000
GT422	Midvaal	B2	108871000	14159	12529	5.52	152439	45	8896469	96775	543	27126	Broadbased targeting	41	81892000
MP303	Mkhondo	B3	25297000	37433	246	5.52	170150						N/A	40	213000
LIM365	Modimolle	B3	28110000	20107	5050	4.50	203000	17					Self-targeting	38	6783000
LIM367	Mogalakwena	B2	105959000	79432	4541	4.50	514660	0	5331986	310319	309	18537	Self-targeting	50	19277000
GT481	Mogale City	B1	261314000	54011	51574	5.52	174427	16	19219114	368039	677	59532	Broadbased targeting	110	177199000
FS163	Mohokare	B3	25843000	10515	1573	4.37	71556	40					Self-targeting	54	0
LIM364	Mookgopong	B3	5807000	8557	1020	4.50		14					Self-targeting	18	48000
DC33	Mopani	C	292547000	240664	45332	4.50	157729	0	61855039	1101856	3939	227961	Self-targeting	669	59002000
FS201	Moqhaka	B2	32912000	35360	32914	4.37	129868		5618395	160774	931	46535	Self-targeting	68	28000
NW371	Moretele	B4	65115000	54051	4307	5.52	380313						Self-targeting	16	31471000
NW375	Moses Kotane	B4	134234000	63459	62966	5.52	185188	67					Broadbased targeting	101	37988000
WC043	Mossel Bay	B2	73557000	32849	27326	7.00	315185	57	6200664	90686	6892	344577	Broadbased targeting	54	7613000

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MP302	Msukaligwa	B2	38182000	43469	36000	5.52	218425	28	3153712	150657	402	23800	Broadbased targeting	40	11985000
FS185	Nala	B3	40688000	22648	8209	7.17	27824	117					Self-targeting	51	27443000
FS171	Naledi (FS)	B3	13060000	8374	4739	4.37		4					Self-targeting	13	4965000
NW392	Naledi (NW)	B3	20923000	17721	3532	5.52	151585	9					Self-targeting	41	8150000
NC062	Nama Khoi	B3	24296000	12114	4250	7.17	96200	4	1586858	47352	243	13204	Self-targeting	25	18234000
EC105	Ndlambe	B3	32083000	18492	8663	7.55	510300	15	2797000	61413	349	17461	Geographical targeting	10	4024000
NMA	Nelson Mandela Bay	A	512235000	324292	83660	7.55	68361	20	70202390	1156547	4327	204838	Self-targeting	1500	64673000
KZN252	Newcastle	B1	247936000	84272	21773	4.70	207637	75	21386180	365964	684	47910	Self-targeting	190	0
FS203	Ngwathe	B3	31269000	34380	16476	5.52	212710		8016527	120703	694	34709	Self-targeting	62	12896000
FS193	Nketoana	B3	38730000	16586	3478	4.37	65195	37					Self-targeting	77	672000
MP324	Nkomazi	B4	95542000	66761	12456	5.52	165851	47					Self-targeting	268	2158000
DC15	O .R. Tambo	C	272471000	298131	250548	7.60	183118	197		1370200			Broadbased targeting	549	23060000
WC045	Oudtshoorn	B2	22003000	15567	5854	7.00	157595	10					Self-targeting	79	219000
WC032	Overstrand	B2	94931000	27826	25406	7.00	246804	125	5175404	81557	524	26214	Self-targeting	51	0
NC094	Phokwane	B3	29430000	14443	1870	7.17	99148	6					Self-targeting	27	22029000
FS195	Phumelela	B3	7471000	10588	10214	4.37	117208	6					Self-targeting	24	296000
MP304	Pixley Ka Seme (MP)	B3	8651000	20417	2400	5.52	163500	122					Self-targeting	20	167000
LIM354	Polokwane	B1	196713000	178757	26941	4.50	225704	7	19374833	634372	1494	141966	Self-targeting	152	124582000
WC052	Prince Albert	B3	4647000	2325	2268	7.00	64600	5					Broadbased targeting	5	0
NW385	Ramotshere Moiloa	B3	3718000	32821	939	5.52	138412		3702665	152373	496	24792	Consumption-based targeting	17	8000
GT482	Randfontein	B2	63901000	32875	30495	5.52	182700	107	6830000	151603	1037	51848	Broadbased targeting	30	48124000
NC075	Renosterberg	B3	4658000	4211	479	7.17	22839	13					Self-targeting	31	2000000
NC061	Richtersveld	B3	2380000	3130	1101	7.17	112833		488692	12061	55	2822	Self-targeting	6	919000
NW373	Rustenburg	B1	462390000	121019	3409	5.52		20	23497749	555618	2855	142725	Self-targeting	197	265874000
NC081	Saldanha Bay	B3	1804000	1710	509	7.17	143778	2					Self-targeting	9	56056000
WC014	Saldanha Bay	B2	89928000	24653	7006	7.00	285516	34	12737466	100584	532	24020	Self-targeting	31	56056000

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FS191	Setsoto	B3	26800000	30423	26496	4.37	128767	5	7722716	112763	271	27140	Self-targeting	73	0
DC43	Harry Gwala DM	C	135978000	89714	10689	4.70	252719	34		464819			N/A	196	10555000
NC078	Siyancuma	B3	20325000	6351	2910	7.17	94700						Self-targeting	20	475000
NC077	Siyathemba	B3	6903000	4028	2328	7.17	145941		1383968	21731	68	3163	Self-targeting	17	249000
NC091	Sol Plaatjie	B1	194417000	60299	4997	7.17	170163	11	14971985	249653	912	51030	Self-targeting	147	66338000
WC024	Stellenbosch	B1	86823000	33074	12591	7.00	108984	43	10042690	157916	759	37950	Self-targeting	125	15316000
MP313	Steve Tshwete	B1	81772000	40462	32956	5.52	166119	27	11036711	231797	897	44854	Self-targeting	84	10473000
EC106	Sundays River Valley	B3	10871000	14749	2968	7.55			1859789	54713	191	9587	Self-targeting	12	991000
WC015	Swartland	B3	42426000	19740	5103	7.00	164116	34	4630434	115355	515	19046	Self-targeting	43	20491000
WC034	Swellendam	B3	10001000	5894	5894	7.00	340182	13	1212948	36418	125	6250	Self-targeting	11	0
MP321	Thaba Chweu	B3	41490000	28852	8088	5.52	157378	1					Self-targeting	37	239000
LIM361	Thabazimbi	B3	22455000	25581	225	4.50	155167	9					Self-targeting	24	13872000
KZN225	The Msunduzi	B1	403123000	159233	9562	4.70	100820	11	34386293	623198	1674	83694	Self-targeting	255	313816000
WC031	Theewaterskloof	B3	39993000	17767	2955	7.00	130049	27	3692063	110312	604	30190	Self-targeting	41	7986000
NC076	Thembelihle	B3	3475000	3431	3431	7.17	186700	4	990749	15803	63	2659	Broadbased targeting	10	1000
MP315	Thembisile	B4	166673000	73720	66849	5.52	118603						Self-targeting	73	96966000
NW402	Tlokwe	B1	54922000	43643	11182	5.52		24	13915767	164552	832	39874	Self-targeting	39	8452000
FS182	Tokologo	B3	1814000	9981	1265	4.37	112857	12					Self-targeting	7	64000
NC085	Tsantsabane	B3	4631000	11434	2445	7.17	179600	98	1021706	35321	66	3280	Self-targeting	5	2019000
EC132	Tsolwana	B3	8510000	10095	2091	7.55	138696		1307500	33409	157	8250	Self-targeting	23	61000
NW382	Tswaing	B3	6297000	25488	3000	5.52	174850						Self-targeting	20	660000
FS183	Tswelopele	B3	7219000	11791	10280	4.37	116813		2999063	47695	267	13358	Broadbased targeting	16	2944000
NC071	Ubuntu	B3	3782000	5329	1886	7.17	77923						Self-targeting	13	685000
DC21	Ugu	C	340380000	109031	38155	4.70	308207	47	18261779	727920	3883	58416	Broadbased targeting	396	45818000
DC22	Umgungundlovu	C	296175000	56409	152	4.70	120022	61	34386293	1025217	1674	83694	Self-targeting	180	70731000
MP323	Umjindi	B3	24480000	22808	6239	5.52	374944	2	3464154	67731	381	17712	Self-targeting	18	0

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DC27	Umkhanyakude	C	190296000	75919	12000	4.70	200725						N/A	204	58482000
NC072	Umsobomvu	B3	24185000	8108	2094	7.17	101391	166	802176	28560	87	6553	Self-targeting	23	268000
DC24	Umzinyathi	C	133730000		13254	4.70	35140						Self-targeting	1	8442000
DC23	Uthukela	C	206706000	117501	10256	4.70	133242	27	14026330	673842	3378	168906	Geographical targeting	433	47329000
DC28	Uthungulu	C	289730000	103521	1223	4.70	425835	57	29706777	914366	1589	40010	Self-targeting	97	29250000
NW401	Ventersdorp	B3	2886000	12516	11868	5.52	229429						Self-targeting	7	110000
DC34	Vhembe	C	509384000	249322	140098	4.50	146136	29	28729853	1305799	4571	251912	Broadbased targeting	1614	1000000
MP311	Victor Khanye	B3	56518000	15533	12736	5.52	193545	4					Broadbased targeting	33	22377000
GT483	Westonaria	B2	115071000	28034	17973	5.52		4	4500000	113498	807	40353	Self-targeting	78	102882000
WC022	Witzenberg	B3	17621000	12444	4126	7.00	112750	17	4390453	117571	509	25424	Self-targeting	36	0
DC26	Zululand	C	297709000	120649	74170	4.70	114929	10					N/A	422	73678000