An Account of Demand Management Strategy in Response to Cape Town’s Two Most Recent Droughts: 2004-5 and 2015-17

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Abstract

Droughts in Cape Town are common and can be devastating to the city’s water supply. The way the City of Cape Town and the Department of Water and Sanitation choose to respond to water scarcity during drought periods has changed and continues to change as the city’s water demand increases. Forms of response to drought include supply-oriented strategies like infrastructure repair, tariffs, and desalination, or demand-oriented strategies like restrictions on water consumption. This report attempted to record the impact of the City of Cape Town and Department of Water and Sanitation’s demand-oriented responses, specifically, water restrictions. The drought periods that were examined were 2004-5 and 2015-17.

Water restrictions are characterized by levels and are enforced by the City of Cape Town during periods of water scarcity. They are often described with confusing language, and sometimes it is unclear when one level of restriction ends and another begins. Levels 1, 2, 3, and 3b were defined in this report in order to understand the effect they have had on consumers. During the 2004-5 drought, only levels 1 and 2 were enforced. During the 2015-17 drought, levels 2, 3, and 3b were enforced. In 2015-17, the first water restrictions were enforced when dam levels were close to 70% full, whereas in 2004-5 the first water restrictions were not enacted until dam levels were close to 55% full. As intended, these water restrictions resulted in a change in water consumption. Water restrictions in 2005 forced average daily water consumption in peak summer months down to about 1,000,000 Ml/day when the population of Cape Town was close to 3,000,000. In 2016, average daily water consumption in peak summer months decreased to 950,000 Ml/day when the population of Cape Town was closer to 3,600,000. Both the speed at which restrictions were enacted and the effect they had on consumption is an indication of the improved impact of the city’s demand management strategy.

The literature referenced in this report shows that Cape Town has shifted from using supply-oriented strategies to more demand-oriented strategies. This report concludes that of the demand-oriented strategies used, water restrictions have been heavily relied on in both drought periods. In 2015-17, water restrictions were enforced sooner, and with more strict limitations. This is an indication that the City was more prepared to enact its demand management strategies, and according to consumption data, did so with more success. The general trend analysis that was produced shows that although Cape Town’s water consumption is generally increasing due to population growth, it is possible that individual consumption is generally decreasing.

This report offers a solid contribution to the bigger challenge of understanding how strategies for water management are shifting in Cape Town.
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Introduction

1.1 Background: Climate

Cape Town is the second largest city in South Africa, situated in the Western Cape. Although most of South Africa experiences summer rainfall, as shown in Figure 1, much of the Western Cape experiences a mediterranean climate, consisting of hot, dry summers and mild, rainy winters. Drought is a natural characteristic of South Africa’s climate (Hoffman et al., 2009). The years 2015-2017 have been characterized by prolonged drought in the Western Cape. The most recent drought before 2015 spanned from 2004 to 2005, and before that from 2000-2001.

Figure 1: A representation of South Africa’s varying climate (cnx.org, n.d.)

Drought is a concern for communities because it can lead to a decrease in existing and future water supply. Cape Town gets its water from The Western Cape Water Supply System (WCWSS), which has infrastructure owned and operated by both the City of Cape Town and the Department of Water and Sanitation (Dwa.co.za, n.d.). When drought strikes the region, both the City of Cape Town and the Department of Water and Sanitation respond in order to allocate water resources effectively.

The strategies that the City of Cape Town and the Department of Water and Sanitation have employed to respond to drought and water scarcity have varied. Increasing Cape Town’s supply of water is one way to tackle the impacts of droughts. For example, The Berg River Project began in 1989 in order to add the Berg River Dam to the WCWSS. Since inaugurated in 2009, the yield of the WCWSS has increased by about 18% (tcta, n.d.). However, to meet a growing population with a growing demand for water, new plans to augment the City’s water supply are necessary.

Demand management is an another way the government responds to drought. According to the Department of Water and Sanitation, the City has invested heavily in implementing water conservation and water demand management (WC/WDM) measures (Dwa.gov.za, n.d.). One way to
do that is to impose consumption restrictions on Cape Town residents’ water consumption. During dry periods, restrictive levels of water consumption reduction have been imposed to save 10%, 20%, and 30% of water for levels 1, 2, and 3, respectively. The first water restrictions were imposed in early 2003, and have periodically changed level and meaning since then.

Both the supply-oriented approach and the demand management approach are responses to drought. How soon these approaches should be implemented in the face of water scarcity, which one should be prioritized given the city’s budget, and how they should be enforced are questions that water experts are wrestling with. The complexity of the interconnected drivers that determine how soon these responses are enacted is explained in Chapter 2 of *Water and The Future of Humanity* (Braga et al., 2014). Likewise, the direction in which Cape Town’s future response to drought might take is explained by Ohlsson and Turton’s *Turning of a Screw* (2000). Both these pieces of theory are relevant in framing Cape Town’s changing response to drought, and are outlined in Section 4.2.

This report does not predict or attempt to recommend future strategies for the City of Cape Town. This report simply frames how the City of Cape Town and the Department of Water and Sanitation have responded with water restrictions to the two most recent droughts in 2004-5 and 2015-17, and how they have changed Cape Town’s water consumption.

1.2 Aims and Objectives

This project aims to document how the City of Cape Town and Department of Water and Sanitation’s implementation of water restrictions since the 2004-5 and until the drought in 2015-17. This is done by observing how and when restrictions were enforced and how they impact water consumption trends.

The objectives of this project are to:

- Describe the conditions of the droughts in 2004-2005 and 2016-2017 with rainfall data obtained from the South African Weather Service.
- Describe the meaning of water restrictions that have been enforced by the City of Cape Town to limit water consumption during droughts.
- Create a timeline of water restrictions to map how soon they were enforced after symptoms of drought were prevalent.
- Highlight the trends of Cape Town’s water consumption patterns from 2000-2017 from water consumption data obtained from the City.

A Review of Relevant Literature

2.1 Introduction

The following review will provide background and context by summarizing established literature on which this report relies. This review is split into four sections that explain the competing definitions of drought, the mechanisms of climate change and its relevance to drought, theory that relates to water demand management, and literature describing Cape Town’s previous water consumption patterns and water supply and demand management strategies.
2.2 Definition(s) of Drought

The definition of drought can vary among the scientific community because there are many factors that can contribute to a drought event. Drought can be caused by a period of low rainfall, increased temperatures, or limited availability of social resources and infrastructure needed to capture and treat water effectively in dry periods. As a result, a number of different classifications of droughts have emerged and dominate fields of scientific drought literature.

A number of scientists classify a drought event as being one of three categories: meteorological, hydrological, and socio-economic (Hisadal and Talleksan, 2000 and Wilhite, 2000). A meteorological drought is characterized by a prolonged lack of precipitation. A hydrological drought indicates that there is a reduction in river flows, groundwater and reservoir levels. A socio-economic drought is defined as a lack of some economic service or good. The supply of that good or service usually cannot meet the demand of the population (Wilhite, 2000). These definitions can be flexible and intertwined. For example, an area could experience some lower-than-usual rainfall and river flow, but is considered a socio-economic drought because the real problem is the lack of dam and reservoir infrastructure needed to sustain a rapidly growing urban population.

Dracup et al., (1980) and Arnell (2009), agree that droughts can be separated into categories as well, citing both hydrological and meteorological droughts with similar definitions. However, instead of classifying socio-economic droughts, they include the category of agricultural droughts. An agricultural drought is defined as a deficit of soil moisture (Arnell, 2009). Other factors that can change the threshold for a dry event to be called a drought are the time period over which the event is analyzed, and the method of choosing the geographic region in which the drought occurred (Dracup, 1980).


Of the authors mentioned, all, including Lloyd-Hughes (2013), can agree on a general definition of drought. A drought can be defined as a temporary deviation from normal water-related conditions (Hisadal and Talleksan, 2000 and Lloyd-Hughes, 2013 and Dracup, 1980 and Wilhite, 2000 and Arnell, 2009). There is a plethora of literature on the classifications of drought, but the most relevant and applicable were included in this section.

2.3 Impacts of Climate Change and a Growing Population on Water

It is largely agreed upon in the scientific community that increased human production of greenhouse gas emissions and other pollutants have contributed to climate change, which, as a result, impact the natural systems that maintain the state of our environment. According to the Intergovernmental Panel on Climate Change (IPCC) 2014 assessment report, “Many aspects of
climate change and associated impacts will continue for centuries, even if anthropogenic emissions of greenhouse gases are stopped” (IPCC, 2014, p.16).

Increased warming due to climate change has inspired research on the frequency of droughts in the future. Many climate change scenarios predict that the frequency of extreme weather events, like drought, is likely to increase in the future (Arnell, 2008 and Stringer et al., 2009, Mukheibir and Ziervogel, 2007 and Sheffield and Wood, 2008 and Midgley et al., 2007 and Tadross et al., 2005). The link between climate change and frequency of extreme weather events is supported, but is also debated. Some studies done on rainfall and dryness in the Western Cape conclude that there is no reason to believe frequency of drought has or will increase (Hoffman et al., 2009 and Warburton and Schulze, 2005).

Despite the speculation of correlation between climate change and frequency of drought, the global population perceives drought as a concerning impact of climate change. According to a survey done by the Pew Research Center in 2015, the majority of surveyed people are more concerned about drought than extreme rain events, high temperatures, or rising sea levels caused by climate change (Stokes, Wilkes and Carle, 2015). More specifically, 59% of those surveyed in Africa name drought as the number one concern of climate change (Stokes, Wilkes and Carle, 2015). It is clear that despite a lack of definitive evidence linking climate change to increased frequency of drought, drought is still the one of the most devastating natural phenomena that affect people’s livelihoods.

Like climate change, another pressure on our natural environment is the rapidly growing human population. As of 2015, the global population reached over 7 billion, 7.3% of which accounts for the South African population. South Africa’s population has an annual growth rate of about 1.1%, but Cape Town’s growth rate is closer to 2.2%, an indication that Southern Africa has one of the fastest growing rates of urbanization compared to other regions in the world (Desa, 2014 and Desa, 2015). It is expected that global, national, and urban population growth increase the pressure on water and other vital resources (Schewe et al., 2014).

It is predicted that global water supply will continue to decrease with increased climate variability and water demand will continue to increase with a growing population. Such a severe discrepancy in diminishing supply and growing demand of water has triggered a need for effective water management strategies. However, it is also acknowledged that in developing countries, these tasks prove to be more challenging since access to social resources can be limited (Arnell, 2008 and Stringer et al., 2009 and Ziervogel et al., 2011).

2.4. Related Water Demand Management Theory, in general

Water demand management is an increasingly popular global topic as many regions around the world are struggling with water scarcity. Although there are numerous pieces of literature pertaining to this topic, two pieces in particular are most relevant for this project.

2.4.1 Drivers of Change During a Period of Resource Scarcity
In Chapter 2 of Water and The Future of Humanity, Braga et al. (2014) have developed a set of assumptions related to what drives resource demand, and what drives those drivers of resource demand. Figure 2 is a flowchart of concepts that affect and are affected by the main drivers of water demand.

![Figure 2: A schematic to explain the feedback mechanisms and interconnectedness of societal drivers (Braga et al., 2014).](image)

Braga et al. (2014) assert that the main drivers in this chart are quantifiable, like GDP and urban culture. In contrast, the drivers of main drivers are less quantifiable, like value systems and perceptions of a society. Main drivers can affect or be affected by climate change, available resources, and/or human well-being through feedback loops. Drivers of main drivers affect and are affected by main drivers but in a much slower fashion. Braga et al. (2014) explain that, “‘Main drivers’ and ‘Climate change’ will increase in significance during the foreseeable future, whereas ‘Drivers of drivers,’ ‘Water and other resources,’ and ‘Human well being’ may either be more important as drivers or have a decreasing influence on the complex interactions in the system” (Braga et al., 2014, p. 24). In other words, the connections between these concepts are all interlinked and can affect each other in different ways and at different rates.

A main take-away from Figure 2 is that the drivers of main drivers take more time to affect main drivers than main drivers take time to affect water and other resources. Likewise, issues of water scarcity will take a great deal of time to affect the drivers of drivers like social perceptions or political codes of conduct. This means that if water is scarce and affecting citizens’ well-being, it might take a great deal of time for social perceptions to prompt a political response to change the situation. Then, if a decision based on water demand management is to be enacted, it will take time for that decision to manifest into urban culture and change water consumption habits. Once these habits have immersed

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themselves into society, the economy, and culture, water demand will decrease in a faster manner. Water demand management is not one goal to achieve, it is a series of complex and very slow feedback mechanisms that rely on external factors that can’t be controlled or predicted.

2.4.2 Evolution of Water Demand Management Theory

In “The Turning of a Screw” Ohlsson and Turton assert that a country must not only manage the scarcity of natural resources, but also manage the scarcity of social resources, which will, in turn, help manage the natural resources (Ohlsson and Turton, 2000). For example, in the case of a drought, water is a natural resource, but the Water and Sanitation Department within the government is a social resource. Managing the scarcity of water must also require managing the effectiveness of the government department that is in control of water infrastructure, allocation, and legislation.

Alternating between managing natural resources and the social resources that manage the natural resources is not a checklist. Natural resource scarcity cannot be eradicated without addressing the social resource scarcity almost simultaneously. To address both resource scarcities, the process can be compared to the “turning of a screw” (Ohlsson and Turton, 2000). Ohlsson and Turton explain this analogy by stating, “At each stage of social adaptation to water scarcity, the need for input of social resources is higher. The turning of the water screw represents an oscillation between scarcity of the natural resource water; alternating with a second-order scarcity of the social resources required to successfully adapt to the first-order water scarcity” (Ohlsson and Turton, 2000, p. 3).

As the “screw” turns, a society dealing with resource scarcity progresses through four stages of water management evolution. The stages are called “Getting more water,” “End-use efficiency,” “Allocative efficiency,” and “Adapting to scarcity” (Ohlsson and Turton, 2000). The “getting more water” phase involves increasing the supply of water resources, for example building more water infrastructure. The “end-use efficiency” phase involves decreasing excess demand and waste to get “more use per drop” of water (Ohlsson and Turton, 2000). This could take the form of investments in existing water infrastructure repairs to minimize leakages, or improving the efficiency of treatment plants. The “allocative efficiency” phase requires a social restructuring in order to get “more value per drop” of water (Ohlsson and Turton, 2000). This could take the form of restricting water use for luxury goods like wine from vineyards and allocating it only to normal goods like staple crops. The last, and final phase, “adapting to scarcity,” is the sustainable solution that requires long-term planning to sustain the social resources required to avoid resource scarcity in the future.

The goal of water management, in general, is to reach a state of consumption that does not exceed the annual renewable amount of water. The process to achieve this is what Allan and Karshenas refer to as “Natural Resource Reconstruction” (Allan and Karshenas 1996). A visual representation of how these stages occur in relation to water demand can be seen in Figure 3.
Ohlsson and Turton assert that a society passes through the four stages outlined in Figure 3 in order to achieve a level of sustainability of social resources through natural resource reconstruction. The blue curve is water demand, the red curve is the continually growing population of a society, and the green curve is the sustainability level of social resources. The blue water demand curve continues to grow until the allocative efficiency stage can be achieved, and then a society can work towards adapting to scarcity.

Ohlsson and Turton assert that these are the levels of water demand management that global communities should understand and strive to achieve. For example, a city like Cape Town in a drought-prone region will first begin to increase the amount of water they can contain by building infrastructure like dams and reservoirs. If water demand continues to increase, solutions to achieve end-use efficiency like repairing leaks or damaged infrastructure to minimize waste water will be increased. If water demand continues to increase beyond the point of supply, then allocative efficiency efforts like changing how much water is used for agriculture instead of for industry should be enacted. After social restructuring, water demand will decrease, to reach a high level of sustainability for social resources.

2.5 Water Demand Management Strategy and Consumption Patterns in Cape Town

Past water management strategy that has been used by the City of Cape Town and the Department of Water and Sanitation is imperative in understanding how current water demand management strategy has developed and will continue to develop. Winter and Sinclair-Smith, in review), as well as Frame and Killick (2014), assert that Cape Town’s water management strategy has
already begun its transition from a primarily supply-oriented approach to a more demand-oriented approach (Winter and Sinclair-Smith, in review and Frame and Killick, 2004). Cape Town’s Water Demand Management strategy was seldom a considered approach before the 1990’s (Frame and Killick, 2004). Frame and Killick explain that, “Towards the end of 1999 it became increasingly clear that there was a need to adopt an integrated water resource planning approach to manage the future water demand” (Frame and Killick, 2004, p. 684). As a result, an “Integrated Water Resource Planning” (IWRP) study was conducted in 2001 by the City of Cape Town. The results of the IWRP study indicate that “a significant saving in water demand could be achieved through the implementation of water demand management initiatives” (Frame and Killick, 2004, p. 685).

Increasingly, Cape Town “has progressively shifted from a supply oriented philosophy to one where strategies for reducing the demand are integrated with supply management” (Frame and Killick, 2004, p 684). Frame and Killick assert that demand management initiatives will have a significantly lower implementation cost, a shorter time frame, and be more environmentally and socially acceptable.

“An Overview of Water Conservation and Demand Management in the City of Cape Town” was published by the City of Cape Town in 2007. The purpose of the study was to “provide a decision support framework to facilitate timeous decision making of appropriate water resource interventions necessary to ensure that future water demands can be met on a sustainable basis” (Ketteringham, 2007, p. i). The conclusions of the study were that Water Services Authorities in Cape Town need to maintain a presence in the community and continually develop water conservation and water demand management strategy. This includes continuously reviewing water tariffs, implementing measures of water conservation to ensure water is being used efficiently, and developing education programs to ensure sustainability in the future.

The Department of Water and Sanitation completed the “Western Cape Water Supply System Reconciliation Strategy Study” in 2007 with updates in 2014 and 2015 (Dwa.gov.za). The study looked into water supply schemes that could serve the growing water demand to support the WCWSS. The graph in Figure 4 shows the WCWSS system yield in 2007, as well as the actual and adjusted water use, and the expected growth in water requirements until 2025, given the high growth scenario (Dwa.gov.za). It is clear that the completion of the Berg River Dam in 2009 boosted the system’s yield, but other strategies for supply augmentation are required in the future. WC/WDM is required simultaneously in order to shift the high-growth requirement curve and prolong the need for supply augmentation.

It is clear from this literature that as of 2007, that water demand management has become an important strategy for the government to use when facing drought.
Although it is clear that the transition from supply-oriented management to demand-oriented management is underway, Midgley and Methner assert that “The focus [of South Africa’s water demand management] remains on disaster relief rather than on risk reduction and adaptation for long term resilience” (Midgley and Methner, 2016, p. 1). It is evident that although Cape Town is moving in a sustainable direction, more urgent steps towards long-term solutions for the future need to be taken.

In order to further understand Cape Town’s transition towards prioritizing water demand management, it is essential to understand the literature on consumption patterns of the population. Following the drought of 2004-5, household water consumption was recorded but the breakdown of activities of water consumption was harder to identify. A study by Nina Viljoen published in 2012 showed the amount of water used in various income categories in traditional households as well as families with additional dwellings in Cape Town. The study found that laundry is the highest use for water in all households across income categories. Other findings include the number of water-saving fixtures per household, number of people with pools, toilet usage frequency etc. (Viljoen, 2012). A study done by Tamara North on how information affects water consumption as a method of water management was published in 2006. The most significant finding was that large-scale consumers (those who consumer >50KI of water per month) who received feedback and an information leaflet about consumption, reduced their consumption by about 16% (North, 2006). Understanding how consumers respond to prescriptive water management strategies like leaflets, is similar to understanding how they might respond to water restrictions. Both authors agree that there is a lack of data and literature relating to Cape Town residents’ consumption patterns (North 2006, and Viljoen, 2012). Ketteringham also asserts that, “A clear understanding of consumer demands and demand
patterns is however currently not available and therefore it may only be necessary to restructure the curtailment measures in order to achieve predefined demand reduction targets” (Ketteringham, 2007, p. iv).

It is clear that although water demand management literature exists, data on consumption patterns and the true nature of response to drought is lacking. This report aims to partially fill in these gaps by providing data and analysis related to consumption patterns and water restrictions in an organized and consolidated form.

3. Methodology

3.1 Data Collection

Three relevant data sets were obtained for this report. The first set consists of rainfall data obtained from the South African Weather Service (SAWS) to describe the conditions of the 2004-5 and 2015-17 droughts. An email correspondence and a disclosure statement was filled out to retrieve the data (see Appendix). An excel file of raw data from the SAWS weather station at Cape Town International Airport provided monthly rainfall data for the years 2000-2016 and the first 3 months of 2017. The disclosure statement form that needed to be filled out is appended in this report.

The next two sources data were obtained from the City of Cape Town, which were graphs showing dam level percent fullness and daily water consumption in Cape Town from 2000-2016 and the first 2 months of 2017. The City of Cape Town’s Open Data Portal has these same raw data sets ranging from 2012-2017. In order to get data preceding this time period, an email correspondence was necessary. However, raw data was not available for public release and so graphs of dam level and water consumption data and were collected for this larger time period.

Population data was retrieved from census polls from Statissa.gov.za. This was used to analyze data, and is detailed in the following section.

3.2 Data Analysis

From the obtained monthly rainfall data, an annual average was taken from the monthly raw data in order to observe and compare entire years with extremely low or high rainfall.

Because raw dam level and water consumption data was not available for public release, values had to be estimated to do further analysis. Average peak values of water consumption from the graph from 2000 to 2017 were estimated by eye and recorded. Using these estimated values, a new graph was created in order to illustrate average daily peak water consumption for a given year in Cape Town. This graph, however, did not show daily peak water consumption per person for a given year. Only 73% of water production in Cape Town can be accounted for by residences (Winter, in review). A second graph was created using the same values divided by the annual population of Cape Town and multiplied by .73. Trend lines for both of these graphs were generated in Excel’s built in functions.

3.3 Organization of Timeline and Government Legislation
In order to find legislation and other government documentation, Cape Town’s Open Document Centre was frequently used. The Open Document Centre is a website set up by the City of Cape Town, which provided this report with all of the by-laws, water restriction legislation and policy documents. The other large portion of documents came from the Western Cape Government website, WesternCape.gov.za under the documents section. The remaining sources of water-related content came from news websites or other government websites.

3.4 Limitations and Challenges

Due to the short time length this project spanned, it was difficult to retrieve more extensive and detailed data. After communication with several governmental departments, it was made clear that more precise weather and water data can take 90 days to retrieve. Another limitation was not having access to raw data for the dam level and water consumption graphs. To analyze this data, estimations of peak water consumption were extracted from the given graphs to create data points, but a more precise analysis could have resulted if raw data had been found. This project’s data also only spanned a time period from January 2000 until March 2017. The water crisis of 2015-17 has continued well into May 2017, and is likely to continue longer. More data collection should be continued to complete the analysis for the drought period of drought of 2015-17.

Another limitation to this study was the accuracy of the data received. It is possible that the rainfall figures generated from the stations provided are not representative of the region where the dams are situated in. More research into how the catchment sites represent Cape Town is needed to understand how accurate this data is.

Results and Discussion

4.1 Introduction

The following results and discussion section is split into five parts in order to effectively address the aim and objectives of this report more clearly.

The first section describes the conditions of the drought of 2004-5 compared to the drought of 2015-17 through rainfall data in Cape Town from 2000 to 2016.

The second section is a chart detailing the meaning of water restrictions enforced by the City of Cape Town. This chart serves as a documentation of consolidated available information about water restrictions in order for future researchers to access.

The third section is a timeline, of water restrictions overlaid on a graph of dam levels in Cape Town from 2000 to 2017. This was done in order to observe how soon water restrictions were enforced after dam levels began to noticeably decline.

The fourth section shows the trend of Cape Town’s water consumption from 2000 to 2016 in an attempt to understand how water consumption has changed after water restrictions were enforced.

The fifth and final section summarizes these results and relates them to the water demand management theory presented in Section 2.4. This narrative serves to explain how Cape Town’s
government response to drought can change as climate conditions vary, population increases, and water consumption fluctuates.

4.2 The Condition of Cape Town’s Two Most Recent Droughts: A Comparison of Rainfall Data

Figure 5 shows average annual rainfall documented from Cape Town’s catchment at SAWS weather station near Cape Town International Airport. Average rainfall was extremely low in the years 2000, 2003, 2010-2011, and 2015-2016. The years 2000-2001, 2004-5, and 2015-17 were considered droughts in the City of Cape Town, so low rainfall during these time periods is to be expected.

![Figure 5: Average total rainfall per year from 2000-2016](image)

It is evident from Figure 5 that 2010-2011 was also a dry period, characterized by low rainfall. It can be speculated that this time period was not considered a drought by the City of Cape Town due to the fact that the Berg River Dam was inaugurated in 2009 which increased Cape Town’s water supply. Rainfall may have been low for this time period, but because the supply of water was augmented by the Berg River Dam, total dam levels did not drop in the same way they did in other years (see Figure 6). It is also possible that the rainfall catchments do not reflect accurate rainfall data for Cape Town since the catchment sites are located many kilometers away from the city center.

Figure 6 shows daily dam percentage fullness in Cape Town’s dams from the years 2000-2017. Although the city of Cape Town experienced low rainfall in 2010-2011, dam levels did not drop below 60%. In contrast, in 2000-2001, 2004-5 and 2015-2017, which were considered official drought periods, dam level fullness reached at least below 40%, as seen in Figure 6.
Low rainfall in 2003 contributed to the drought in 2004-5. Likewise, a lack of rainfall in 2015 contributed the drought of 2015-17. Lack of rainfall in 2010-11 was also observed, however 2010-2011 was not a drought. This period was considered a dry period in Cape Town. In early 2011, Dr. Peter Johnston, a climatologist at UCT reported that, “water restrictions could become necessary” (Saving Water, 2011). The city was on the brink of water restrictions during this time, but dam levels did not drop and so water restrictions were not enforced.

The 2010-2011 dry period is an instance where the definition of drought can differ in the scientific community. The droughts of 2004-5 and 2015-17 were meteorological and hydrological as they were characterized by low rainfall and low reservoir, or dam, levels (Hisadal and Talleksan, 2000 and Dracup, 1980 and Wilhite, 2000 and Arnell, 2009). However, in 2009-11, the hydrological component of the dry period was not seen, as dam levels did not reduce. There was still a meteorological drought because rainfall was unusually low, but its impact was not large enough to characterize it as a drought for the City of Cape Town, and so no water restrictions were enforced.

It is clear from the results of this data analysis that rainfall data reflect the increased severity of the current drought compared to the drought of 2004-5, as well as explain the unusual dry period of 2010-11.

### 4.3 Water Restriction Consolidated Chart of Information

The purpose of Table 1 is to outline the differences of water restriction levels enforced by the City of Cape Town. Water restriction legislation information is not always conveyed to the public as intended, and so a clear consolidation of definition is helpful for this report.
<table>
<thead>
<tr>
<th>Level 1 (Normally in place)</th>
<th>Level 2 (When dam levels are lower than the norm)</th>
<th>Level 3 (When dam levels are very low)</th>
<th>Level 3B (When dam levels are approaching critically low)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
<td>10%</td>
<td>20%</td>
<td>None found</td>
</tr>
<tr>
<td>Irrigation/Watering</td>
<td>Sprinklers permitted, but watering a garden, sports field, park, or other grassed area using potable water between 10:00 and 17:00</td>
<td>No watering between 9AM-4pm or within 24 hours of rainfall. Irrigation (e.g. hose pipe/sprinklers) is only to take place on Tuesdays, Thursdays and Saturdays during approved hours, and for no longer than an hour in total.</td>
<td>ONLY with bucket, no limited times. No watering within 24 hours of rainfall</td>
</tr>
<tr>
<td>Cars/boats/vehicles</td>
<td>A hosepipe used for washing vehicles, boats, and caravans shall be fitted with an automatic self-closing device</td>
<td>Informal car washes must use buckets rather than hosepipes.</td>
<td>Washing (using potable water) of vehicles and boats only allowed if using a bucket.</td>
</tr>
<tr>
<td>Pools</td>
<td>None found</td>
<td>Automatic top-up systems for swimming pools and garden ponds are not allowed. Furthermore, the use of a pool cover is recommended</td>
<td>No portable pools. Manual topping up of swimming pools allowed only if fitted with a pool cover. No automatic top-up systems are allowed.</td>
</tr>
<tr>
<td>Alternative Water source (boreholes/wells)</td>
<td>None found</td>
<td>Customers should ensure that they display signage to this effect clearly visible from a public thoroughfare.</td>
<td>must ensure they display the appropriate signage to this effect clearly visible from a public thoroughfare. All wellpoints and boreholes must be registered with the City and used efficiently to avoid wastage and evaporation.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Golf courses, parks, sports facilities schools</td>
<td>None found</td>
<td>None found</td>
<td>No new landscaping unless using non-potable water</td>
</tr>
<tr>
<td>Cost (Per kl)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1: (0 &lt;6 kl)</td>
<td>R0</td>
<td>R0</td>
<td>R0</td>
</tr>
<tr>
<td>Step 2: (&gt;6 &lt;10.5 kl)</td>
<td>R14,89</td>
<td>R15,68</td>
<td>R16,54</td>
</tr>
<tr>
<td>Step 3: (&gt;10.5 &gt;20 kl)</td>
<td>R17,41</td>
<td>R20,02</td>
<td>R23,54</td>
</tr>
<tr>
<td>Step 4: (&gt;20 &gt;35 kl)</td>
<td>R25,80</td>
<td>R32,65</td>
<td>R40,96</td>
</tr>
<tr>
<td>Step 5: (&gt;35 &lt;50 kl)</td>
<td>R31,86</td>
<td>R48,93</td>
<td>R66,41</td>
</tr>
<tr>
<td>Step 6: (&gt;50 kl)</td>
<td>R42,03</td>
<td>R93,39</td>
<td>R200,16</td>
</tr>
<tr>
<td>(Western Cape Government, 2017)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: A comparison of water restriction levels enforced by the City of Cape Town**

From Table 1, it is clear that water restrictions are more strict as the level of restriction increases. The purpose of this table is to consolidate the available information on water restriction levels in order to understand how the meaning of restrictions changes water consumption. It is also presented here for future research on this topic because the meaning of enforced water restrictions is not always clear or easy to locate. Understanding the increased severity of water restrictions helps to illustrate Cape Town’s improved water demand management strategies.

### 4.4 Water Restriction Timeline in Relations to Dam Levels

Figure 7 shows significant dates of when the City of Cape Town government enforced water restrictions. These dates have been overlaid on a graph of dam percentage fullness for the years
2000-2017. Figure 7 serves as a timeline to track how soon government responded to low dam levels with water restrictions over the years.

From Figure 7, conclusions about the speed of government response to low dam levels can be made. During the 2004-5 drought, Level 1 restrictions were enforced when the dams were about 55% full and Level 2 restrictions were enforced when the dams were about 40% full. During the 2015-2017 drought, Level 2 restrictions were enforced when the dams were about 70% full. This was possibly due to climatic forecasting and understanding that due to low rainfall (see Figure 5) water would need be conserved. This foresight and quick response is an indication of Cape Town’s preparedness, and more efficient application of its drought management strategy.

### 4.5 Water Consumption Trends in Cape Town 2000-2016

Daily water consumption data for the City of Cape Town from 2000-2016 is shown in Figure 8. The raw data was not obtained for this report.
In order to better understand water consumption trends in Cape Town, peak values of water consumption were estimated and extracted from Figure 8. These peak estimation values occurred in January and February, the hottest months of the year in Cape Town. These values were plotted in Figure 9. Figure 9 shows a trendline of increasing estimated average peak daily water consumption from 2000-2016. More specifically, each data point represents a daily peak value of water consumption for a given year that was estimated from the peaks in Figure 9. The increasing trendline indicates that peak water demand is continuously increasing. Intuitively, this result is not surprising because as Cape Town’s population grows, it is expected that water consumption will increase.

In order to observe how water consumption has changed not within a city but among individuals, population data was collected from census polls for the years 2000-2016. The data points in Figure 9 can be divided by the changing population in order to see how estimated average daily peak water production per Cape Town resident has changed since 2000. It must also be recognized that the water consumption data points do not only account for water consumption among residents,
but also water consumption for industrial and commercial use. As a result, the distribution of water usage must be accounted for, which is shown in Figure 10.

![Figure 10: Percentage of water consumption by activity in 2013/14 (City of Cape Town, 2015).](image)

Figure 10 shows that in 2013 and 2014, about 73% of water usage in the City of Cape Town was used in residences including informal settlements, flats, housing complexes, and houses. Although the distribution of water may have changed before and since this data was taken in 2013 and 14, it is not available in this report. The number 73% will serve as an estimated value of water consumption for residences for the purposes of this report.

The graph in Figure 11 uses the same points as the graph in Figure 9, except the estimated average daily peak consumption values are scaled by the growing population of Cape Town, and only 73% of the water produced by Cape Town is considered. The estimated average daily peak values were adjusted. Therefore, each data point in Figure 11 represents the estimated average daily peak consumption per person in the City of Cape Town for a given year from 2000-2016.
Figure 11: Peak water production per person in the City of Cape Town in L/day from 2000-2016.

The trendline in Figure 11 is decreasing, indicating that individual daily peak water consumption is decreasing with time. This could be due to a number of factors, including effective legislation and water restrictions, decreased infrastructure leakage and waste, better household water-saving technology, and/or a better informed and environmentally conscious society. Figure 9 is an indication that total water consumption may be generally increasing, but Figure 11 is an indication that individual water consumption may be generally decreasing. Although the City of Cape Town still must address the issue of increasing total water consumption, water demand management strategies may be decreasing individual consumption.

The graphs in Figures 8, 9 and 11 all contain two clear outlying points at 2005 and 2016 that show very low peak water consumption. It is evident that these points of water consumption were due to water restrictions and water scarcity during the droughts of 2004-5 and 2015-17. Consumers responded to Cape Town’s restrictions in 2004-5 and 2015-17, but reduced their consumption more in 2015-17. Water restrictions in 2005 forced average daily water consumption in peak summer months down to about 1,000,000 ML/day when the population of Cape Town was close to 3,000,000. In 2016, average daily water consumption in peak summer months decreased to 950,000 ML/day when the population of Cape Town was closer to 3,600,000. Both the speed at which restrictions were enacted and the effect they had on consumption is an indication of the improved impact of the city’s demand management strategy.

4.6 A Discussion of Theory
From previous literature, it has been established that the City of Cape Town is transitioning from water supply solution management to water demand management (Winter and Sinclair, in review and Kenningham, 2007). Both Figures 9 and 11 indicate that the city reduced its water consumption a great deal after restrictions were put in place. As seen in Figure 9, although total water consumption may continue to increase, this is largely affected by population growth. Figure 11 is an indication that water demand per person may be decreasing. The question remains, has Cape Town transitioned from the point of end-use efficiency to allocative efficiency, as Ohlsson and Turton expect, before reaching a sustained level of social resources? (Ohlsson and Turton, 2000). It is not possible to conclude solely from these results, but some important conclusions can be made.

In order to match the results in Section 4 with the theory provided in Section 2, a narrative of Cape Town’s change in water demand management is as follows:

The 2004-5 drought as well as the drought in 2000-2001 as well as numerous previous droughts have brought attention to water scarcity in Cape Town. Water management strategy has been on the City’s radar for decades, however this narrative details only the most recent large-scale changes.

In 2004-5, as a means of water demand management strategy, level 1 and level 2 restrictions were enforced which resulted in a decrease of peak water consumption of about 250,000 Ml/day from the previous year. Although water demand management strategy was enforced during this time, the restrictions were enforced when dam levels were already at about 60%. Room for improvement in the timing of demand response was needed.

In 2009, Cape Town established its presence in the “getting more water” phase that Ohlsson outlines in his theory (see Section 2.4.1). In 2009, the Berg River Dam was inaugurated. Although 2009-2011 were particularly hot and dry years, even worse than 2004-5, dam levels did not drop the way they did in 2004-5 (see Figure 6). This supply-oriented solution proved to be effective, although costly and time consuming. This kind of solution is what has worked for Cape Town and other communities around the globe for a long time. Now, with an uncontrollably increasing population and continuing climate change, this kind of solution is not sustainable.

Usually, in a drought or dry period consumption decreases for a short period of time. However, from 2009-2011, when a dry period hit, water consumption did not decrease because the Berg River Dam increased water supply (see Figure 7, 8 or 10). This is an indication that the supply-oriented solution did not diminish Cape Town’s continually growing demand. The supply-side solution only prevented the symptoms of drought, low dam levels. It did not provide a long-term or sustainable solution that was required in a region of increasing water demand and increasing rain variability.

In 2015, water restrictions were once again enforced after no enforcement since 2004-5. In 2015 dam levels were closer to 70% full when the restrictions were enforced, and indication of improvement in response time. It can be assumed that Cape Town is in Ohlsson’s end-use efficiency phase (See section 2.4.1), as it has improved its demand management strategy.
The next of Ohlsson’s phases for Cape Town to enter is the phase of allocative efficiency. The goal is to get more value per drop of water, because getting more water and more use out of each drop of water is no longer an option (Ohlsson and Turton, 2000). Cape Town can reach this point by a reduced reliance on surface water. Cape Town’s water is supplied almost entirely by surface water. In order to get more value per drop, tapping into groundwater sources would essentially be the same as receiving water without taking away from the allotted annual renewable water that is provided by rainfall.

For now, the government has relied more heavily on water restrictions to get through the 2015-17 drought. However, political decisions like water restrictions take time to enact as well as be implemented into society, as shown by the schematic of feedback loops introduced by Braga et al. (2014) in Section 2.4.1. The government is acting faster, as evidenced by the timing of events shown in Figure 11, but it is time to fully transition to a phase of allocative efficiency.

Conclusions and Recommendations

5.1 Conclusions

This report provided a number of results. The first set of results were descriptions of the conditions of the current drought period as compared to the most recent past drought period. It is clear that the 2015-17 had lower rainfall than the 2004-5 drought. 2010-2011 was also considered a dry period with similarly low rainfall. The opening of the Berg River Dam explains why this period was not considered a drought, because an increasing water supply allowed dam levels to remain unaffected by the extreme climate. It could also be possible that the rainfall data is not necessarily representative of Cape Town’s rainfall because of the distance from catchment sites.

The second set of results provided a table defining water restrictions, and a timeline indicating when water restrictions were enforced. Based on the water restriction timeline in Figure 7, it be concluded that the City of Cape Town and the Department of Water and Sanitation are responding quicker to dam level decline than previously in 2004-5.

The third set of results were a variety of water consumption trends to help paint a narrative of the impact of Cape Town’s water management. Although total water consumption in the city may be increasing, the habits of individual consumption of water may be decreasing. In 2015-17 Cape Town consumers reduced their consumption during drought by a larger amount than consumers did in 2004-5, indicating that water restrictions may have become more effective. More specifically, water restrictions in 2005 forced average daily water consumption in peak summer months down to about 1,000,000 Ml/day when the population of Cape Town was close to 3,000,000. In 2016, average daily water consumption in peak summer months decreased to 950,000 Ml/day when the population of Cape Town was closer to 3,600,000. These results indicate an improvement in Cape Town’s water demand management strategy as a response to drought.

The final part of this section was a discussion of theory as it related to the results obtained. It can be concluded that Cape Town has transitioned from the idea that the city needs to get more water, to the idea that the city needs to use the water more carefully. The next step to move towards is how to
get more value of the existing water, possibly by relying more on groundwater than surface water. It can also be concluded that the reason that some of Cape Town’s water management strategies have not been effective is that it takes time for the interconnected feedback loops relating to water demand to produce change (Braga et al., 2014).

5.2 Recommendations

Further research can be done on this topic. It is possible that the drought of 2015-2017 will continue well into the end of 2017 and possibly into 2018. More data can be added to the existing data sets, timelines, and tables. The accuracy of the rainfall data also comes into question as it is possible that the weather station by SAWS near Cape Town International Airport is not a good representation of rainfall in the center of Cape Town. Water consumption data was also estimated for the analysis of this report because raw data was not obtained. If raw data can be obtained for future research, more definitive conclusions can be made.

A continued analysis of Cape Town’s government response to drought in the form of water demand management will help outline how the City of Cape Town can continue to strive for a sustained level of social resources. This report provided a small contribution to the large topic of government response to drought, and so more research should be done to complete this analysis.
References:

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Ohlsson, Leif and Turton, Anthony, 2000. THE TURNING OF A SCREW.


Viljoen, N., City of Cape Town Residential Water Consumption Trend Analysis.


Appendix:

Below is a Disclosure Statement from the South African Weather Service that was necessary to fill out in order to obtain the temperature and rainfall data used in this report.
Disclosure Statement

**SCHEDULE 1**

Please note: The South African Weather Service will only accept customer requirements noted on this disclosure statement and not from any other correspondence.

<table>
<thead>
<tr>
<th>Full Names</th>
<th>Hendrik Arminia</th>
</tr>
</thead>
<tbody>
<tr>
<td>University/Organisation</td>
<td>University of Cape Town</td>
</tr>
<tr>
<td>Student Number of Application</td>
<td>B09FA00502</td>
</tr>
<tr>
<td>Email address</td>
<td><a href="mailto:minhba0052@myuct.ac.za">minhba0052@myuct.ac.za</a></td>
</tr>
<tr>
<td>Telephone</td>
<td>+27 11 776 6323</td>
</tr>
<tr>
<td>Supervisor</td>
<td>Kevin Winter</td>
</tr>
<tr>
<td>Project/ thesis title</td>
<td>An Analysis of the Evolution of Government Response to Cape Town’s Two Most Recent Droughts: 2004-5 and 2015-17</td>
</tr>
<tr>
<td>Current registered degree (e.g. BSc)</td>
<td>BSc</td>
</tr>
<tr>
<td>Expected completion date YYYY-MM-DD</td>
<td>06/06/17</td>
</tr>
</tbody>
</table>

This South African Weather Service reserves the right to request, in any form, from the student proof of registration for the Degree at the University.

Please ensure you complete all required sections in the template for approval.

It would be helpful in classifying the types of storms Cape Town has experienced if you include rainfall and temperature data for Cape Town for the past 17 years (2000-2017).

DATA REQUIRED (Please indicate the year for which data is required, month, temperature, wind and sun data):

Rainfall data: [Provide data, 0000-0000-00]
Temperature data: [Provide data, 2000-2017]
Disclosure Statement

I hereby accept that:
- SWNS will be acknowledged in the resulting publication or when published, for the data it provided.
- SWNS will be credited with access to the final results in printed or electronic format.
- This document is intended as a preliminary draft only.

Signature of the User: [Signature]
Date: 5/4/17

(Ensure the document is signed in the presence of a witness to the validity of the document and ensure a signature.)