Urban Water Management Challenges and Achievements in Windhoek, Namibia

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Abstract

This paper gives an overview of the main challenges and achievements faced by Windhoek's water management sector. The paper highlights pertinent issues arising from increased water demand, and also explores current and future water supply augmentation options. Water planners experience management challenges as a result of a combination of factors, mainly, lack of funds and staff, limited expertise, poor communication between stakeholders, and weak regulation and enforcement. In order to meet these challenges water managers need to develop more robust and resilient strategies, including greater focus on water demand management.

Key words: urban water management, City of Windhoek, water demand, water supply, Namibia

1. Introduction

Urban growth in developing countries is increasing at an unprecedented rate. This has caught many city managers off guard, with the result that many cities are struggling to maintain and support service delivery. The expansion of cities due to population growth, rural-urban migration and industrialization has tremendously increased the demand for water. These challenges are putting substantial pressure on local water authorities and water planners to satisfy growing urban water demand (Abderrahman 2000).

This is even more challenging for developing arid countries such as Namibia, the driest country in sub-Saharan Africa. Namibia has a very hot and dry climate with erratic rainfall patterns. This is the result of two natural weather factors: firstly, annual rainfall patterns for the country are low and highly variable, and secondly, much of Namibia is exposed to extremely high evaporation rates. It is estimated that roughly 97 percent of rainfall is lost through evaporation. Therefore the arid nature of the country alone means Namibia's fresh or potable water is an extremely precious and scarce resource. Windhoek, the country's capital, is characterized as very hot and dry. According to the Namibia National Weather Bureau (2003), the average annual rainfall for Windhoek is only 360 mm.

Satisfying growing water demand has necessitated the construction of additional costly water projects. This represents major technical, management and financial challenges to policy makers and water managers. This paper describes the development of urban water demands and supplies, and the urban water management practices in Windhoek. It also examines the present challenges and achievements, and the measures required to achieve effective urban water management.

2. Windhoek situation

As the capital city and seat of government, Windhoek comprises the largest urban and industrial development in the country. The bulk potable water supply scheme serving the city is owned and operated by NamWater, the national bulk supplier of water in the country. The so-called "three dam system" (explained below) transferring water to the Von Bach Water Treatment Plant (VBWTP), near the town of Okahandja, comprises the bulk of the NamWater supply scheme for the Central Areas of Namibia, including Windhoek. Other supply sources include the Windhoek reclamation scheme, and groundwater in the Windhoek and northern aquifers.

2.1 Urbanization

Urbanization in developed countries was a result of rapid industrialization, whereas in developing countries like Namibia it comes as a result of people seeking better standards of living. Rapid urbanization is a distinguishing characteristic of contemporary Africa and driven largely by rural-urban migration (Indongo 2015). Africa is becoming much more urbanized, with cities large and small harboring the majority of the population.

In Namibia, urbanization occurred rapidly after independence, when the racially-motivated mobility restrictions of apartheid were abolished and people could move freely. According to the 1991 Namibia Population and Housing Census, the urban population of Namibia was 28% of the total population. Subsequently, this increased to 33% in 2001 and further to 42% in 2011 (Namibia Statistics Agency 2012). Although there has been an overall increase in urban population in Namibia, Windhoek has been by far the major focal point of urbanization. Its population increased from 13.7% in 2001 to 16.2% in 2011 and, according to a report by Namibia Statistics Agency (2014), is expected to constitute 36% of that population by 2019. The 2011 Namibia Population and Housing Census shows that the country's urban population grew by 49.7% between 2001 and 2011. Much of this growth is attributed to demographic shifts in the form of rural-urban migration leading to the rapid development of informal settlements on the outskirts of Windhoek. This has seen the city's population increase from 233,529 in 2001 to 325,858 in 2011. Currently, in 2019, according to the projections in Namibia Statistics Agency's report (2014), the city's population has increased to roughly 430,000.

Due to the high urban population influx over a short period, the City of Windhoek (CoW), has come under tremendous pressure to supply sufficient water. CoW's limited financial resources combined with the size of the urban population, constrain the development of adequate urban infrastructure, particularly water supply.

2.2 Population Growth

The increase in the proportion of people living in Windhoek is due not only to migration but also natural growth of the existing population. Population growth and urbanization are forcing rapid change, leading to a dramatic increase in demand for drinking water. According to a report from CoW (2016), Windhoek's annual population growth rate is currently 4.4%, implying a population doubling time of 16 years.

Because of rapid population growth, per capita water resources have decreased steadily and will continue to do so. The geographic distribution of Namibia's water resources has not been consistent with that of the population, especially since National Independence in 1990. Hence, there is a growing need for more water transfers from greater distances from the capital.

2.3 Industrialization

Besides urbanization and population growth, steady economic growth in Namibia since independence has significantly added to water demand in Windhoek, due to rapid industrialization (Remmert 2016). CoW records show that business water connections increased from 4,832 in 2012 to 8,495 in 2015 and that this sector's water consumption more than doubled over the same period (Remmert 2017).

2.4 Climate Change

According to Dirkx et al. (2008), temperatures in Namibia have been increasing since about the 1970s. The numbers of days on which the temperature exceeds 35°C have been increasing, while the numbers with temperatures below 5°C have been decreasing, suggesting warming. Later onset and earlier cessation of rains, resulting in shorter seasons in most areas, have also been observed, and there has been a statistically significant decrease in the number of consecutive wet days in various locations, while increases in rainfall intensity have been observed.

The most probable long term effects of climate change with respect to water supply are increased maximum temperatures, with accompanying higher evaporation rates from surface reservoirs, and more frequent droughts with an estimated decline of 20% in average rainfall in the Central Area of Namibia (Midgley et al. 2005; Turpie et al. 2010).

3. Water Supply

CoW's water supply is based on the use of surface- and ground- water. The bulk water supply system to Windhoek is drawn from the Central Area of Namibia (CAN). Its main sources of fresh water are the Grootfontein–Omatako Eastern National Water Carrier (ENWC) and three large, interlinked reservoirs – the Omatako, Von Bach and Swakoppoort dams – also called the three-dam system. A pipeline connects the Omatako Dam (capacity 43.5 Mm^3) in the north and the Swakoppoort Dam (63.5 Mm^3), in the west with the Von Bach Dam (48.6 Mm^3) in the central area, on which CoW relies heavily for fresh water. The distances to the three dams are 200, 100 and 70 km respectively. They are supplied with surface water from ephemeral rivers, as well as groundwater transferred from aquifers in the karst area about 450 km north of the city. When operated together, the safe yield of the three dams is approximately 20 Mm^3/a, based on 95%

assurance of supply. However, due to erratic inflow into the three-dam system, chronic water shortages have been experienced in Windhoek since 1990 (van Rensburg 2006).

Other water sources critical to Windhoek are boreholes from which groundwater is abstracted and the reclaimed water from the Goreangab Water Reclamation Plant, which are owned by CoW. In 1993 CoW installed a dual pipe system to ensure that all municipal parks, gardens and sports fields could be irrigated with treated sewage effluent, replacing between 5 and 7% of potable water demand.

However, over the years, Windhoek's increasing water demand has steadily outgrown the supply from the three-dam system. It has been estimated that by 2012 all existing water resources in the CAN, excluding the Windhoek Aquifer (WA), had been developed to their full potential. Windhoek's water demand grew from around 21 to around 27 Mm^3/a from 2005 to 2014 (Government of Namibia, 2014).

3.1 Water supply augmentation

According to Lahnsteiner and Lempert (2007), all developable water resources within 500 km of CoW have been fully exploited and the supply from the three-dam system cannot be guaranteed (owing to both climate change and population growth in northern Namibia). The city must, therefore, get water from other areas. Furthermore, water demand in the CAN since 2013 has exceeded the 95% safe yield of the resources available, and CoW's water demand alone is expected to nearly double by 2050 – from the current 27 to approximately 50 Mm^3/a (Murray et al. 2018). The city's population is expected to reach 790,000 in 2050.

3.1.1 Windhoek Aquifer

At the start of the 1990s, with the anticipated increasing demand and the threat to water supply security posed by droughts and climate change, a number of water supply augmentation proposals were put forward. In 1997 the option of recharging the WA artificially was considered the most favorable and cost-effective. The idea of using the WA as a water bank, whereby treated surface water would be transferred to the aquifer for safe storage and use when needed, was taken up keenly by CoW and plans to construct a managed aquifer recharge scheme were put in place (Murray et al. 2018).

The WA lies beneath the southern part of the city, and is owned and operated by the CoW. The recharge project is a significant water supply augmentation accomplishment for the city, because the underground storage is not affected by evaporation. Previously CoW's water was stored in dams, exposing it to high evaporation rates. In general, the whole country potentially loses much more water through evaporation than it receives as rainfall (Biggs & Williams 2001; Mendelsohn et al. 2009; Uhlendahl et al. 2010). Further, the aquifer's recovery period is shortened substantially by artificial recharge, which also provides higher water supply security.

The source of recharge water for the WA is surface water from the three-dam system (75%) and reclaimed water (25%). Both are treated to drinking quality standards developed to prevent groundwater quality deterioration, and minimize clogging of the recharge boreholes (Murray et al., 2018).

3.1.2 Windhoek Aquifer Storage and Recovery Capacity

Considering the growing demand, and the threat of drought and climate change, CoW decided to increase the aquifer's storage and recovery capacity to its maximum potential. By 2011, twenty additional boreholes – ten each injection and abstraction – had been drilled with combined capacities of 675 (injection) and 745 m^3/hr (abstraction). In 2016 twelve additional boreholes (up to 500 m deep) were drilled, primarily for abstraction, and, in 2017, more deep abstraction boreholes (400 to 500 m) were drilled. The aim is to use as much of the aquifer's storage as possible, as this will significantly enhance water supply security (Department of Water Affairs 2010; Murray et al. 2018). In the 2015/16 drought, water from the WA did give the city water security, because the aquifer had been recharged via the boreholes previously.

Plans to expand the aquifer recharge scheme are already in place because of the city's increasing water demand. The aquifer's useful storage capacity is estimated at 90 Mm^3, or about three times current annual water demand. As all of this water is not accessible to the existing boreholes – they do not go deep enough – new, deeper, boreholes are being drilled (Remmert 2016). Therefore;

1. The rate of artificial recharge of WA will increase to 12 Mm^3/a by 2019.

2. The boreholes will be equipped for drought abstraction of 19 Mm^3/a from 2019.

3. The storage capacity of the water bank will be increased from 41 to 71 Mm^3/a after completion of the boreholes and infrastructure, from 2018/19

3.1.3 WA pollution hazard

As noted, the WA is in the south of Windhoek, within the boundaries of two residential areas – Kleine Kuppe and Cimbebasia – an industrialized area (Prosperita) and Kupferberg Landfill. At Kupferberg, two cells are used for waste disposal. General household, commercial and industrial wastes are disposed of in the general cell, while hazardous wastes go to the hazardous cell. To prevent leachate leakage contaminating the soil and/or the WA, the cell is lined to inhibit leakage to the substrate as far as possible (Hasheela 2009). CoW strictly monitors the WA and the catchment. The Kupferberg landfill has had no measurable impact on water quality in the WA since waste disposal started around 2000.

To minimize the pollution threat to the WA, CoW has imposed strict regulations to protect it. These require CoW to be compensated by anyone causing pollution to the WA, whether intentionally or not. The polluter also bears the cost of dealing with the damage caused.

The regulations also provide for a new "conservation" or "groundwater protection" land zone, covering the entire southern part of the city. No industrial or other type of business that could pollute the WA will be permitted in the zone. There is also a buffer strip, which acts as a no-building zone, south of the Windhoek Bypass to the east (Dentlinger 2005).

The WA is expected to act as a buffer in times of acute water shortage. When fully developed, the aquifer is expected to provide security for two or three years as the sole water resource during drought conditions.

3.2 Direct Potable Reuse (DPR)

Windhoek is well known for pioneering direct potable reuse (DPR) and has been practicing it since about 1968, when the first treatment plant was built, after Windhoek's natural springs started drying up due to increased water use. The plant was initially designed to produce 27,000 m^3/d, but, because of continuous demand increases, has been upgraded from time to time and currently yields around 41,000 m^3/d (Gross, 2016). Up to 35% of the city's water can be supplied from treated sewage via the Gammams Waste Water Treatment and New Goreangab Water Reclamation plants.

Up to approximately 7% of the water used is partially treated and supplied, as noted, for the restricted irrigation of sports fields, parks and cemeteries (Lahnsteiner & Lempert 2007).

The WA and DPR are currently the only functioning augmented supplies in use by the City, but are estimated to be sufficient for only 2 or 3 years, in times of drought. To increase short-term water security, therefore, CoW are considering other augmentation ideas. One possibility is to desalinate seawater, another involves transferring water from the Okavango River by pipeline through the northern regions to CAN. These alternatives pose a number of challenges. For example, the Okavango River is shared by Angola, Botswana and Namibia, and extracting water from it is politically sensitive, so that the bureaucracy could make progress slow. The time, cost and environmental hazards associated with these alternative water sources are also major challenges that need to be addressed urgently.

4. Sector Organizations

4.1 Water Sector Organization in Windhoek

Namibia's water sector reform process began in the late 1990s, and emphasized emulating international practice by separating roles and responsibilities between institutions as well as levels of government (Government of Namibia, 2008). The Government of Namibia (GRN) has also strived to rectify and reform the institutions within the state structure inherited from the former apartheid regime, and tasked with governing water supply, demand and sanitation (Hyens 2005). The Department for Water Resources Management within the Ministry of Agriculture, Water and Forestry (MAWF) is responsible for water resources management and drinking water supply in Namibia. NamWater, a state-owned bulk water supplier that operates dams, pipelines and water treatment plants throughout the country, is in charge of supplying water to Windhoek, after which the CoW is mandated to distribute and sell the water to households and businesses.

5. Windhoek Sector Challenges

5.1 Governance Challenges

Urban water management in developing countries is a multifaceted challenge. The number of factors and stakeholders that need to be taken into account, as well as variable socio-economic situations, make the system complex. Grindle (2007) states that governance plays an important role in urban water management performance.

According to Remmert (2016), weak implementation of plans and policies is one of the most pertinent problems hampering the country's water sector, and arises from inadequate governance structures. Lack of coordination, decentralization challenges and the absence of key governing instruments are also noted as having contributed to the poor governance performance. The GRN also acknowledges the water sector's poor performance and how this has affected efficient water supply provision. For example, the Integrated Water Resource Management Plan (Government of Namibia 2010) reports weak coordination and communication between institutions, and recommends improved coordination between central and decentralized water management structures (Government of Namibia 2014).

Historically, the performance of urban water systems in developing countries has been sub-optimal, and not due only to inappropriate technology. It should be recognized that urban water management poses complex problems that cannot be solved by individual stakeholders. System failures, particularly in developing countries, have arisen partly because of a top-down approach with limited stakeholder involvement. Finding consensus on what the problems are and how to solve them remains a fundamental challenge. The issue is further compounded by the lack of discussion platforms through which businesses and private individuals can engage government (New Era 2016).

5.2 Skills and capacity building

A critical concern affecting urban water management in Windhoek is staff and skills deficit. The main reason is staff moving from the public to the private sector because of more attractive benefits, such as higher salaries, and better career growth and development opportunities (Biswas 2016). To put this into perspective, Sherbourne (2013) shows that GRN had a continuous decline of employee numbers in the water industry from 2001 to 2008, when the total staff complement within state institutions almost halved from 1,160 to 601.

The point is emphasized in the Integrated Water Resource Management (IWRM) Plan 'Review and Assessment of Existing Situation' report which states that: "Staff retention is a difficult issue for all government and private water institutions and service providers because there is a lack of skilled people and a continuous movement of skilled persons between the institutions." (Government of Namibia 2010).

This imbalance of skills between the public and private sectors hinders water management as the expertise available is not aligned properly with the areas in greatest need of it (Remmert 2016). It is fortunate for Namibia that the skills and expertise with regards to water resource management in the private sector remain available for the country's development. Taking this into consideration, and to counter the skills and staff gap within the public sector, the GRN in its IWRM report (2010) indicates that the private sector should be involved in mentoring, and capacity building and maintenance. That this point has been actively pursued is evident from the numerous assessments and plans available focusing on the water sector, and emanating from private firms and consultancies.

5.3 Capital Investment

Availability of adequate funds and their release in a timely manner, to operate and maintain existing water and wastewater facilities in urban areas in developing countries, is a major challenge. Operation and maintenance of existing water supply and wastewater treatment systems, as well as the construction of new systems, are often constrained by lack of funds (Biswas 2006).

In Windhoek, the financial management of many utilities leaves much to be desired. Another severe problem is the long-term and seemingly continuous lack of capital investment in water supply infrastructure rehabilitation and building (Remmert 2016).

To develop a relevant funding strategy it would be necessary to define as accurately as possible the funding or investment gap needing to be bridged. It would also be important to distinguish clearly between capital expenditure and recurrent costs as there are different funding strategies for these.

5.4 Water infrastructure

In most cities, urban water system infrastructure (storage, treatment, transport and distribution) has exceeded its design life, and has not received priority for maintenance and replacement. It is a technological and financial challenge to maintain and upgrade infrastructure such that quality water can continue to be delivered to all sectors, and wastewater adequately collected and treated (Khatri & Vairavamoorthy 2007; Vahala 2004).

In Namibia, water infrastructure has only expanded marginally since Independence (1990), mainly because it is capital intensive and Namibia is a developing country. Remmert (2016) notes that the existing infrastructure is ageing and in poor condition, and recommends that the government prioritize rehabilitation and modernization of existing and degraded water infrastructure, and secure the required funds.

Leakage goes hand-in-hand with depleted infrastructure. The Windhoek Bulk Water Master Plan (City of Windhoek 2004) found that leakage rates in some households were very high due to inferior equipment and lack of maintenance. The leakage on premises varied from 31 to 110 l/d, with an average of 87.8. An acceptable leakage figure might be around 20 l/d. If this could be achieved, the estimated annual savings would amount to about N$ 5.8 million (US$ 1,151,000), calculated at an average selling price of N$ 6.00/m^3 (City of Windhoek, 2004).

5.5 Resource Mobilization

It is a challenge for CoW to manage its own water budget in the context of broader circumstances and to allocate resources. The national budget has repeatedly prioritized infrastructure development in the transport, military and public service sectors, while only limited provisions have been made for water and sanitation (Brown 2016). Because of these competing demands CoW receives inadequate funds for water projects, leading to delays in project execution. Allowing for the time needed to build infrastructure and the cost involved, a proactive strategy is needed to secure funds for short-, medium- and long- term projects, instead of playing “catch up” with water supply and demand.

5.6 Water availability in the informal settlements

The rapid rate of migration to the city since Independence has resulted in the mushrooming of informal settlements on Windhoek’s outskirts. To provide water to them, CoW introduced post- and pre- payment systems. The post-payment system uses a community tap, where a small group of households – usually 5 to 6 – use one tap. Each month the cost is divided between them and paid to a committee member, who then pays the municipality. The pre-payment system which consists of water points, requires each household to use a pre-payment card to access water. Each system has advantages and disadvantages.

Owing to the high annual influx of people, however, the city has not been able to keep up. CoW now grapples to plan and manage the demographic transition processes efficiently, equitably and sustainably. Lewis et al. (2018) show that water supply to the informal settlements has declined progressively and that water accessibility is generally poor. The situation further compounds the challenges to provide drinking water to all residents in the city.

6. Water Demand Management

Globally, urban water resource management has shifted from supply to demand management, because of rapid population growth, periods of severe drought, accelerating demand for water, increased energy costs, the need to postpone large-scale water infrastructure investments due to limited financial resources, and arid or semi-arid climatic conditions (Magnusson 2004).

Due to the number of people moving to the city and a severe drought in 1993, CoW decided that the best way to conserve water in the short- and medium- term was through water demand management (WDM). Accordingly, an integrated WDM policy was initiated in 1994. Its aim was to reduce consumption and improve water use efficiency, especially within the high-income group, by implementing a wide range of measures. The strategy consists of policy issues (including block tariffs), public awareness campaigns, and technical measures.

One of the most effective measures to control water consumption was a block tariff structure, whereby the price of water increases with the volume used. Between 1994 and 1999, residential water use decreased substantially from 201 to 130 l/c/d, which could be attributed partly to the new pricing policy (van der Merwe 1999).

Initially, the block tariff structure reduced water consumption by changing consumers' water use habits and savings exceeding 30% were achieved (van der Merwe 1999). However, over time, water use per capita more or less reached a plateau, despite water rates increasing almost yearly. This indicated that block tariffs should not necessarily be seen as the ultimate tool in urban water demand management and that other measures that produced successful water user responses needed to be explored (Magnusson 2005). In 2015, CoW announced a new "penalty tariff" for individual households that consumed more than 50 m^3/month. The threshold was lowered subsequently to 40 m^3 and residents' basic water tariffs were increased by 10% in 2016 (Haidula 2015).

Windhoek’s implementation of WDM is seen by many as a success story (Udendahl et al. 2010; Magnusson 2005; van der Merwe 1999). The success can be attributed to the dedication and active involvement of the leadership; the holistic approach; the environmentally sustainable reuse of water, and the financial sustainability, as the WDM achieved annual savings up to N$ 6.84 million. Between 1994 and 1999, the policy was the main instrument for successful reduction of about 40% in per capita water consumption. According to Mwendera et al. (2003), at the time, Namibia’s WDM instruments were seen as some of the most advanced and comprehensive in the Southern African Development Community (SADC) region.

However, in spite of this progress, the low budget allocation and inconsistency in implementing the plan affected it negatively. There is strong motivation only during severe droughts and not when water levels are considered sufficient. Appropriate WDM strategies including public and private water-saving measures should continue to be promoted and enforced within the CAN, regardless of the supply situation. Magnusson (2005) also noted that, for WDM in Windhoek to be a success, continuous funding is required.

7. Conclusions

CoW’s water resource management problems are multi-faceted, and cover a wide variety of economic, political and social issues. Current trends indicate that increasing population growth, urbanization and industrialization are unavoidable, and, therefore, one of the major challenges facing the city is meeting the growing demand in the future. Strategic plans for urban water management that incorporate adequate demand and supply analysis are needed. Government, together with stakeholders, should explore funding models for long-term water needs. Establishing and realizing funding models for new water infrastructure is imperative as they are a key requirement for meeting growing water supply demand.

Governance challenges within the water sector contribute to slow progress. Water management is hampered by lack of funds and staff, limited expertise, poor communication between stakeholders, and weak regulation and enforcement. To manage the wide-ranging scope of water responsibilities effectively among all the institutions involved, it is suggested that the current communication strategy be examined and alternative systems of cooperation be considered, to enable alignment of activities and policies These issues need to be addressed if CoW wish to have sustainable socio-economic development in the long-term.

At present, WDM is only used tentatively when there is a water crisis, so society's water behavior changes little once that is over. On the basis of the above, CoW has two choices: to continue with the 'business as usual' or 'do nothing' approach, which, for the most part, looks only at contributing to short-and medium- term water supply. This will lead consistently to inadequate water provision. The alternative is to prepare and plan for the long term, and accelerate WDM efforts by drastically altering the mind-sets of decision-makers, water managers and water users. This might seem a daunting task, but with strong political will and well-organized management, sustainable WDM can be achieved.

Thus far, CoW has managed to provide its citizens and industry consistently with a 24-hour water supply, even during severe drought. Despite the growing water demand pressures, CoW has done well to augment Windhoek's supplies. The latest water augmentation project being artificial recharge of the WA, which contributes significantly to the city's long-term supply. Protecting this vulnerable source should be a high priority. Although management and protection regulations are incorporated for the WA, CoW should strive for an Environmental and Assessment Management Law, to govern the safe and sustainable use of the aquifer.

References

Abderrahman W. A. 2000 Urban Water Management in Developing Arid Countries, *International Journal of Water Resources Development*, *16*(1), 7-20. DOI: 10.1080/07900620048536

Biggs D. & Williams R. 2001 A case study of integrated water resource management in Windhoek Namibia. *Proceedings of the IHP Symposium: Frontiers in Urban Water Management: deadlock or hope?* Marseille June 18–20. IHP-V UNESCO. Maksimovic´, Cˇ. & Tejada-Guibert, J.A. (Eds.). IWA Publishing, London, 10–18. http://www.the-eis.com/data/literature/A%20case%20study%20of%20integrated%20wter%20resource%20management%20in%20Windhoek.pdf

Biswas A. 2006 Water Management for Major Urban Centres. *Water Resources Development*, *22*(2), 183-197. DOI: 10.1080/07900620600690789

Brown R. 2016 *Fiscal Sustainability and Growth: A difficult balancing act. Special Briefing Report No. 12*. Institute for Public Policy Research.

City of Windhoek. 2016 Councilor Organogram. http://www.windhoekcc.org.na/pdf/Councillor%20Ogranogram%202016.pdf (accessed 21 January 2019)

City of Windhoek 2004 Windhoek Bulk Water Master Plan, Windhoek.

Dentlinger L. 2005 City takes action to protect groundwater. The Namibian. https://www.namibian.com.na/index.php?id=13777&page=archive-read (accessed 21 January 2019)

Dentlinger L. 2004 City to recharge aquifer. Economic news. The Namibian https://www.namibian.com.na/index.php?id=2992&page=archive-read (accessed 21 January 2019)

Department of Water Affairs 2010 Strategy and Guideline Development for National Groundwater Planning Requirements. Artificial Groundwater Recharge: Recent initiatives in Southern Africa. http://www.the-eis.com/data/literature/Artificial%20Groundwater%20Recharge%20SA%20DWA%202011.pdf (accessed 28 January 2019)

Dirkx E., Hager C., Tadross M., Bethune S. & Curtis B. 2008 Climate change vulnerability and adaptation assessment Namibia. http://www.landscapesnamibia.org/mudumu/sites/default/files/resources/Namibia%20Climate%20Change%20Vulnerability%20and%20Adaptation%20Assessment.pdf (accessed 02 February 2019)

Government of Namibia 2010 Development of an Integrated Water Resource Management Plan for Namibia: Review and Assessment of Existing Situation. http://www.the-eis.com/data/literature/MAWF_Integrated%20Water%20Resources%20Management%20Plan%20for%20Namibia%202010%2008%2031.pdf (accessed 03 January 2019)

Government of Namibia 2014 The Augmentation of Water Supply to the Central Area of Namibia and the Cuvelai, Interim Report No 1: Part 1.

Government of Namibia. 2008 *Water Supply and Sanitation Policy*. http://portal.unesco.org/fr/files/47370/12670872251Namibia_wsaspolicy.pdf/Namibia_wsaspolicy.pdf (accessed 22 January 2019)

Grindle M. S. 2007 Good Enough Governance. Development Policy Review, 2007, *25*(5), 553-574.

Gross D. A. 2016 Recycling sewage into drinking water is no big deal. They've been doing it in Namibia for 50 years. https://www.pri.org/stories/2016-12-15/recycling-sewage-drinking-water-no-big-deal-theyve-been-doing-it-namibia-50-years (accessed 28 January 2019)

Haidula T. 10/06/2015 City to fine residents for not saving water. *The Namibian*. https://www.namibian.com.na/index.php?id=137916&page=archive-read (accessed 03 January 2019)

Hasheela R. 2009 Municipal Waste Management in Namibia: The Windhoek Case Study: The Windhoek Case Study http://www.the-eis.com/data/literature/Municipal%20Waste%20Management%20in%20Namibia.pdf (accessed 04 February 2019)

Hyens P. 2005 Water institutional reforms in Namibia. *Water Policy 7*, 89-106.

Indongo N. 2015 The effect of urbanisation on housing conditions in Namibia. *International Journal of Humanities Social Sciences and Education*, *2*(7), 1-8. https://www.arcjournals.org/pdfs/ijhsse/v2-i7/1.pdf (accessed 25 January 2019)

Khatri K. B. & Vairavamoorthy K. 2007 Challenges for urban water supply and sanitation in the developing countries. UNESCO-IHE. The Netherlands. file:///C:/Users/elewis/Downloads/CHALLENGES_FOR_URBAN_WATER_SUPPLY_AND_SANITATION_I%20(1).pdf (accessed 04 January 2019)

Lahnsteiner J. & Lempert G. 2007 Water Management in Windhoek, Namibia. *Water Science & Technology*, *55*, 441-448. http://dx.doi.org/10.2166/wst.2007.022 (accessed 06 January 2019)

Lewis E. W., Siyambango, N. & Lendelvo S. 2018. Assessment of accessibility of safe drinking water: A case study of the Goreangab informal settlement, Windhoek, Namibia. *Water Practice & Technology*, 13(4). doi: 10.2166/wpt.2018.096

Magnusson T. S. 2004 Household responsiveness to water demand management incentives in Windhoek, Namibia. *Water Policy*, *6*, 453–471.

Magnusson T. S. 2005 Urban Water Security – Local conditions and regional context: A case study of attitudes and water use behaviour in Windhoek, Namibia. Linköping, Sweden. http://www.dissertations.se/dissertation/68b6fe7e38/ (accessed 05 January 2019)

Mendelsohn J., Jarvis A., Roberts C. & Robertson T. 2009 Atlas of Namibia: A Portrait of the Land and its People. ISBN 978-1-920289-16-4. Published for the Ministry of Environment and Tourism by Sunbird Publishers, Cape Town, South Africa, 3rd Edition.

Midgley G.F., Hughes G.O., Thuiller W., Drew G. & Foden W. 2005 Assessment of potential climate change impacts on Namibia's floristic diversity, ecosystem structure and function. Namibian National Biodiversity Programme. Windhoek, Namibia: Directorate of Environmental Affairs.

Murray R., Louw D., van der Merwe B. & Immo P. 2018 From conceptualising to operating and expanding a MAR scheme in a fractured quartzite aquifer for the city’s water security. https://recharge.iah.org/files/2018/09/2018-p217-223-Murray-MAR-Windhoek-Namibia-p.pdf (accessed 10 January 2019)

Mwendera E., Hazelton D., Nkhuwa D. & Chavula, G. 2003 Overcoming Constraints to the Implementation of Water Demand Management in Southern Africa. *Physics and Chemistry of the Earth Parts A/B/C 28*(20):761-778.

Namibia National Weather Bureau 2003 Weather Bureau Statistics, Windhoek, Namibia.

Namibia Statistics Agency 2012 Namibia 2011 Population and Housing Census Main Report.

Namibia Statistics Agency 2014 Namibia Population Projection 2011 – 2041. https://cms.my.na/assets/documents/p19dn4fhgp14t5ns24g4p6r1c401.pdf (accessed 21 March 2019)

New Era 2016. City of Windhoek water restrictions in place. https://neweralive.na/posts/city-windhoek-water-restrictions-place

Remmert D. 2017 Managing Windhoek’s water crisis: Short-term success vs long-term uncertainty. *Democracy Report*, *18*, 2-16.

Remmert D. 2016 Water governance in Namibia: A tale of delayed implementation, policy shortfalls, and miscommunication. *Democracy Report*, *13*, 1-20.

Sherbourne R. 2013 Guide to the Namibian Economy 2013/14. *Institute for Public Policy Research 3*, 296-8. https://www.namibiana.de/namibia-information/literaturauszuege/titel/guide-to-the-namibian-economy-2013-2014-robin-sherbourne-978-99945-78-14-6.html

Turpie J., Midgley G., Brown C., Barnes J., Pallett J., Desmet P., Tarr J. & Tarr P. 2010 Climate change vulnerability and adaptation assessment for Namibia's biodiversity and protected area system. Strengthening the Protected Area Network (SPAN) Project. Windhoek, Namibia: Ministry of Environment and Tourism

Uhlendahl T., Ziegelmayer D., Wienecke A., Mawisa M. L. & du Pisani P. 2010 Water consumption at household level in Windhoek, Namibia. file:///C:/Users/elewis/Downloads/water_consumption_windhoek_2010_final_report%20(5).pdf

Vahala R. 2004 European Vision for Water Supply and Sanitation in 2030. Water Supply and Sanitation Technology Platform. http://www.wsstp.org/Shared%20Documents/WSSTP%20presentation%20by%20Riku%20Vahala%20

van der Merwe B. 1999 Case study on water demand management in Windhoek. In: *IUCN Water Demand Management Country Study – Namibia*. Prepared for the World Conservation Union (IUCN) Regional programme for Southern Africa. *10*(1), 10-39.

van Rensburg F. 2006 Urban Water Security in the City of Windhoek. Master of Philosophy in Sustainable Development Planning and Management. https://core.ac.uk/download/pdf/37371315.pdf