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An Assessment of the 2015–2017 Drought in Windhoek

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Namibia is the most arid country in Sub-Saharan Africa. In Windhoek, the capital city, accelerated population growth and expanding economic activities, coupled with highly variable rainfall and multiyear droughts, have jeopardized water security and put enormous stress on socioeconomic development. This paper offers a review of the 2015–2017 drought and the responses that were implemented during it, with a focus on engagement with the public, industries, and public institutions to achieve water-saving targets. It also considers how the use of the Windhoek Drought Response Plan during the 2015–2017 drought furthered preparedness efforts for future droughts. The assessment ends with a discussion of government responses, challenges faced, and lessons learned—lessons that can hopefully pave the way for more effective responses to future drought situations in the country.

Keywords: Windhoek, Namibia, drought management, climate change, institutional responses, residential water demand management, industry engagement

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INTRODUCTION

The scale of threat to populations throughout the world is on an upward trajectory, as climate variability and extreme weather events increase in both magnitude and frequency (Inter-governmental Panel in Climate Change, 2014). Climate change is projected to reduce renewable surface water and groundwater resources significantly in most dry subtropical regions (intensifying competition among sectors) and increase them at high latitudes (Jiménez Cisneros et al., 2014). These natural stressors, superimposed on existing socioeconomic conditions, will ultimately have adverse impacts on the availability of water resources, food production, energy generation, the environment, and overall incomes and livelihoods all over the world (Water and Climate Change, 2019).

Globally, in 2019, droughts severely affected areas in northeastern China, North Korea, North Ontario (Canada), large parts of Europe, Southern Australia, Angola, Botswana, Namibia, Zambia, South Africa, and Zimbabwe. Current projections indicate that severity of droughts in Southern Africa may increase in both frequency and duration, exacerbating climate-related risks such as overall water and food insecurity in the region (World Bank, 2012; Niang et al., 2014; Funk et al., 2016). Of great concern is that the region supports a great many people, two-thirds of whom are in situations in which endemic water scarcity can be expected (Water and Climate Change, 2019).

Yuan et al. (2016) illustrates that, like in other parts of the world, there is a substantial increase in concurrent droughts and heat waves in Southern Africa. The 2015–2016 flash drought (droughts with a rapid onset and short duration but with high intensity and devastating impacts) that affected the region was characterized by severe heat waves and soil moisture deficit, the highest since 1948. Flash droughts have increased by 220% from 1961 to 2016, and they are likely to further increase in the future (Yuan et al., 2016).

Regarding the following 2019 drought in the region, NASA Earth Observatory (2019) considers it to have been unprecedented. The combination of reduced and late rainfall and long-term increases in temperature threatened the water, food, and energy supplies of millions of people.

In the case of South Africa, the recent Cape Town drought was estimated to have been a 1-in-590-year event (based on historical rainfall records) whose impacts on the people and the economy were exacerbated by poor planning and management of the event (City of Cape Town, 2019).

In the African context, in Namibia, water has always been a scarce resource (Niang et al., 2014; Scott et al., 2018). With frequent dry periods lasting for as long as 4 years, Windhoek, in particular, has had an uphill battle when it comes to water supply. Being not only the nation's capital city but also its largest city, Windhoek supports most of the country's economic activities.

Figure 1 illustrates the high variability in rainfall and runoff to the Windhoek supply reservoirs and highlights the most challenging recent droughts, among them those of 1980–1982, 1994–1996, and 2015–2017.

Leading into the drought of 2015–2017, the 2012–2013 rainy season brought exceptionally low and erratic rainfall, resulting in zero inflow into the Von Bach reservoir, the primary source of supply to Windhoek (Institute for Public Policy Research, 2017), for the first time since the reservoir was built in 1970. This also resulted in a presidential declaration of state of emergency (Haeseler, 2013). Rainfall in 2014 was again highly variable and unpredictable, leading to a prolonged period of drought from 2015 to early 2017 (Scott et al., 2018). Looking back at the data, it is clear that the drought really started with the poor rain and runoff in 2012/2013, yet the effects only became fully visible about 2 years later, when supplies were running dangerously low due to the continuous below average precipitation. Most recently, 2019 saw the lowest recorded rainfall in Windhoek since 1891 and the worst in the last 90 years in Namibia (Shikangalah, 2020).

Through the rapid implementation of targeted drought management interventions, Windhoek thankfully managed to survive this critical period. Without a doubt, this achievement points to some success in the measures employed. However, the narrative also reveals missed opportunities, shows the limited effectiveness of certain initiatives, and illustrates how responses to drought by governments (in this region specifically but also perhaps throughout the world) tend to be reactive, focusing on crisis management rather than a critical level of preparedness (Wilhite et al., 2014).

Reflecting on the key lessons of the 2015–2017 Windhoek drought enables an assessment of policies that can facilitate the implementation of drought preparedness to increase adaptive

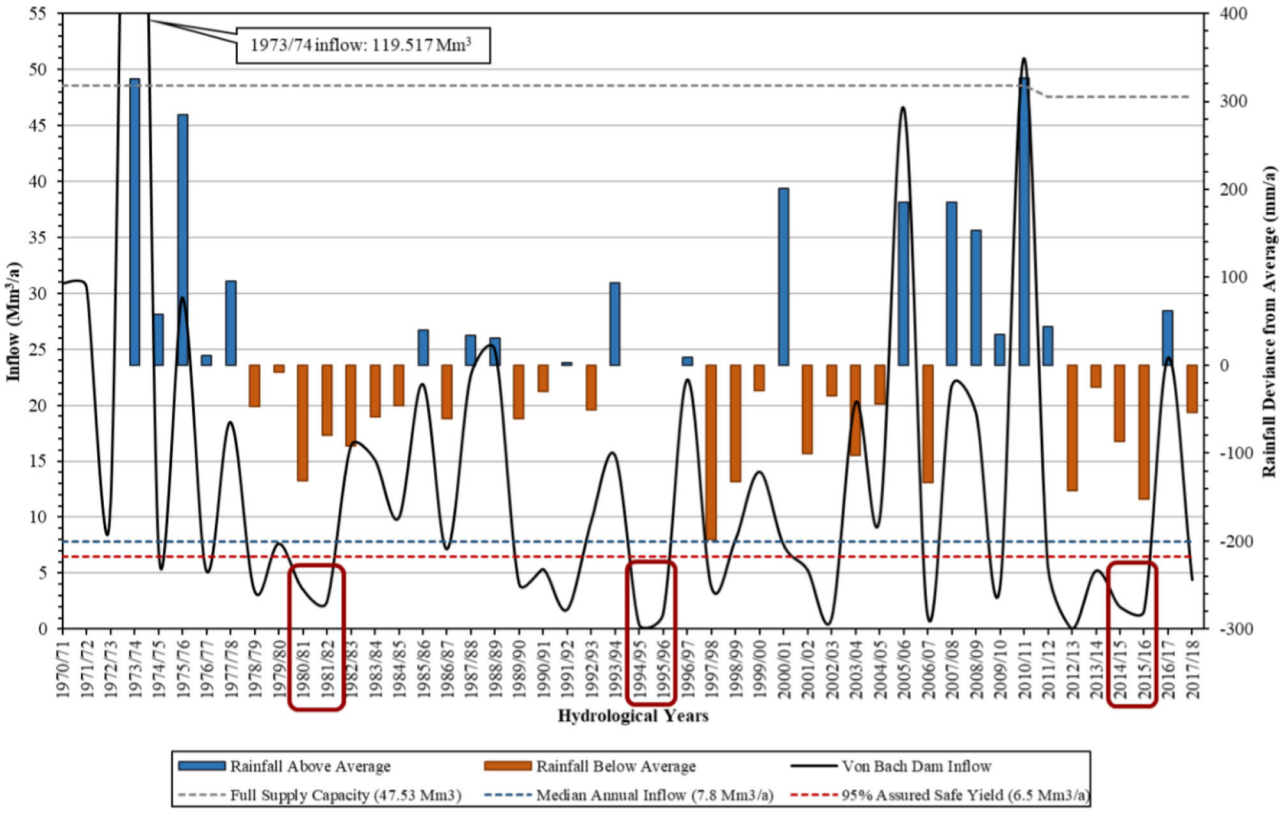

FIGURE 1 | High variability in rainfall and runoff to the Windhoek supply reservoirs, with challenging droughts highlighted. Source: Historical assessment of water resource management and development in Windhoek and the Central Area of Namibia (Bruce and Burger, 2019).

capacity and resilience of water resources management under similar conditions particularly in a region affected adversely by poor governance and planning (Engle, 2013).

With this objective in mind, this paper presents a perspective of the drought response strategies implemented by the City of Windhoek (CoW) and the engagement with domestic and industrial users. This article argues that without long-term communication on the importance of prudent water usage, the motivation to save water during dry periods is unlikely to have the desired response, or at least not for the initial period when this may be required. Next, the article draws on the CoW's experiences in engaging with industries and public institutions to encourage multistakeholder support in complying with drought-response strategies. Experience shows that there can be real difficulties in obtaining support from certain business sectors, with the city administration facing challenges in balancing the economic needs of the various stakeholders while ensuring a sustainable water supply. Finally, challenges and lessons learned are discussed.

BACKGROUND SETTING

Overview of Drought Management in Namibia

Droughts are naturally occurring phenomena in all climates, with characteristics that vary among regions (Food and Agriculture Organization, 2015). They have a complex series of impacts that differ in reach and intensity but often include numerous chain effects that affect all sectors of society either directly or indirectly (Grigg, 2014).

In Namibia, droughts are frequent and thus require well-prepared frameworks to guide timely responses, the most appropriate decisions, and the management of water demand, as necessary. In 1995, the National Drought Task Force was established, and in 1997, the National Drought Policy and Strategy, a long-term drought management plan, was released following a 2-year series of workshops. The document attempted to address the shortcomings of previous drought relief programs and put forward several policy objectives for drought management. A stricter definition of drought was developed according to scientific criteria to estimate both extent and severity of droughts, moving away from what were considered conditions of normal aridity and an emphasis on "disaster drought." Future drought relief was to be based on programs and action plans, which would be funded by the National Drought Fund. These included programs for water supply, food security, health, livestock, and crops (FAO/AGRIS, 1997).

The document later guided the National Climate Change Strategies and Action Plan of 2013. This document in turn was designed to facilitate building adaptive capacity to increase resilience and enhance mitigation (Ministry of Environment and Tourism, 2015). Regarding water resources, the document acknowledges that water scarcity is already a challenge in Namibia and that, historically, it has been a limiting factor for socioeconomic development, a situation that is likely to worsen with climate change.

According to the National Climate Change Strategies and Action Plan of 2013, future features of the water sector in Namibia may include prolonged and more severe droughts and floods, declining soil moisture and increased evapotranspiration, low groundwater recharge, and decreased water availability in both quantity and quality. Proposed strategies to counteract these impacts comprise the following: improving the understanding of climate change and related policy responses; using monitoring and data-collecting technologies for surface and groundwater at the basin/watershed level; harvesting and capturing more water during the rainy seasons; promoting more efficient water use in all sectors; improving access to sanitation and safe drinking water for all, particularly in flood-prone areas; promoting conservation and sustainable utilization of water resources; improving transboundary cooperation on water resources; and supporting institutional and human capacity building in integrated water resources management and use.

At the local-government level, and dealing directly with the consequences of the drought, the CoW Department of Infrastructure, Water and Technical Services developed a Drought Response Plan in 2015 (City of Windhoek, 2015) and broader Water Management Plans in 2017 and 2019 (City of Windhoek, 2017a, 2019)[1]. All these plans provide guidelines on managing water supply and use during drought events, taking the water available in the three reservoirs that primarily supply water to the city as an accurate indicator of the drought's impact on supply. The documents also define drought severity indicators that will be used to choose responses and program elements (City of Windhoek, 2015, p. 3). Responses are intended to increase water supply, reduce water demand, establish water scarcity tariffs, minimize adverse financial effects, implement extensive public information and media relations programs, and/or provide integrated development planning.

The next section provides details on Windhoek's continuous efforts to supply water to its growing population and industrial sector. We then review the 2015–2017 drought and the drought response actions, and focus on public engagement and cooperation with industries and public institutions to achieve water-saving targets.

City of Windhoek

Despite its challenging environment and the poverty of a large portion of its population, the CoW has been a forerunner in water resource management, constantly developing solutions for transitioning to more adaptive systems (Lafforgue and Lenouvel, 2015). The lack of perennial rivers within Namibia means that most of Windhoek's water needs are met by the "three-dam system" of the Von Bach, Swakoppoort, and Omatako dams, which are 70, 90, and 160 km from the city, respectively (Lafforgue, 2016; Murray et al., 2018; Scott et al., 2018). This system supports the NamWater supply scheme for the Central Areas of Namibia (CAN), including Windhoek. NamWater (Namibia Water Corporation Ltd) is the national water agency

[1]The department is responsible for the supply, distribution, and quality of potable water in the urban area.

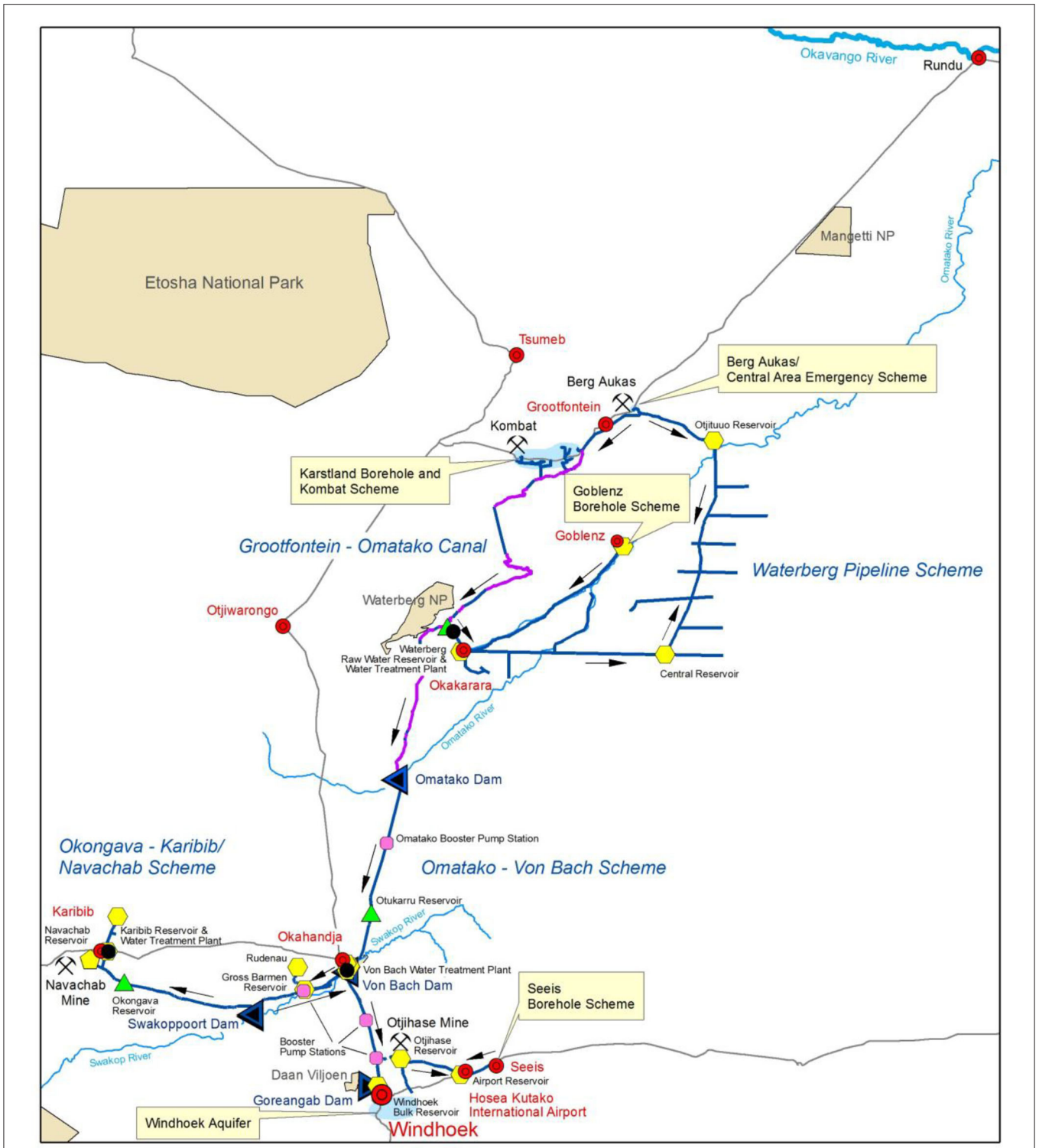

FIGURE 2 | Layout of the bulk water supply infrastructure in the Central Area of Namibia (Bruce and Burger, 2019).

that owns, operates, and maintains this potable water supply scheme (**Figure 2**).

Under average meteorological conditions, water from the three-dam system supplies 70–75% of the city's water. The rest (20–25%) is mostly reclaimed water, with groundwater used on a sustainable basis (5% or less).

By the end of the 1990's, following an extreme dry period and as the urban population continued to grow after independence,

the CoW again looked at ways to supplement its water supply (Lafforgue, 2016). The alternatives discussed included pumping groundwater from the Karst Aquifer (490 km away) and transferring water from the Okavango River (730 km away). Finally, the managed aquifer recharge scheme in the southern extremities of Windhoek was identified as the most cost-effective option, as it could store up to 33 Mm^3 of water, and even 60 Mm^3 when deep aquifers are included (Lafforgue, 2016; Murray et al., 2018). Under this scheme, surplus water from higher rainfall periods would be injected into the aquifer space to reduce water loss to evaporation and to build up a reserve for drier years (Lafforgue, 2016).

Nonconventional sources of water has gained the CoW world recognition as a pioneer in closing the water cycle by adopting direct potable reuse (DPR) at an early stage. Born out of Windhoek's water emergency in the late 1950's, the Goreangab Water Reclamation Plant was introduced into the water supply system in 1968 with a starting capacity of 4,800 m^3/day. The objective was to reclaim potable water directly from domestic sewage effluent to augment conventional sources.

After the drought of 1996–1997, in the absence of feasible medium-term supply alternatives, the CoW expanded capacity and built a new DPR facility. The New Goreangab Water Reclamation Plant was commissioned in 2002 with a capacity of 21,000 m^3/day (Lahnsteiner and Lempert, 2007; Lafforgue, 2016). The continued success of DPR in the city hinges on its public health track record, with no DPR-related health problems recorded to date, as well as its economic viability. Thanks to a direct "pipe-to-pipe" approach, no environmental buffer is needed to store the reclaimed water, reducing the cost of the conveyance and blending of the purified water with other potable sources (Lahnsteiner et al., 2018). Building on this success, the city's dual reticulation system supplies about 2 Mm^3/year of semipurified irrigation water from the old reclamation facility to meet the needs of the city's parks and public greenery (Van Der Merwe et al., 2013). Reducing the demand for potable water ensures that the primary water sources can be used solely to provide potable water to the domestic consumers in Windhoek (Van Rensburg, 2016).

METHODOLOGY

This paper presents a perspective of the institutional responses during the peak of the drought in Windhoek in 2015–2017. However, as mentioned earlier, one could say that the drought started in late 2012. Before the onset of the drought, the last time average rainfall was received in Windhoek was the 2011–2012 rainy season. From then on, rainfall and runoff were far below the historical average, until late in the 2016–2017 season, when relief finally arrived.

The analysis that informs this perspective is qualitative in nature. It includes review and analysis of academic and policy literature, as well as news articles, to understand the significance of drought events in Namibia, in general, and in Windhoek, in particular, as well as the measures taken by the CoW during the 2015–2017 period of the drought. The analyses on the overall government response, the challenges faced, and the lessons learned are based on the first-hand knowledge and experience of the first author, who formed part of the response at the time and worked with representatives of federal and local government institutions.

DOCUMENTING THE DROUGHT RESPONSE PROCESS

Initial Drought Response

Leaning heavily on alternative sources of drinking water, such as managed aquifer recharge and potable reclamation, proved to be key to the CoW's survival of the 2015–2017 drought. Following previous poor rainy seasons and only 197 mm of rain in 2015 (against a long-term annual average of 360 mm), at the end of 2015, the Central Area Forecasting Model (CA-Model) predicted that the water supply from the surface dams would fail by the end of August 2016[2]. With surface water being rapidly depleted, NamWater began pumping groundwater from the Northern aquifers, about 450 km away, to the overall supply system for the Central Area and CoW (Die Republikein, 2015; Lewis et al., 2019). Given the state of readiness and their smaller implementation requirements, groundwater reserves and DPR presented themselves as the most feasible alternatives, and the CoW committed itself to finding ways to immediately increase transfers from these water sources. This was primarily done by rapidly financing and implementing emergency abstraction from the Windhoek Aquifer in line with the Windhoek Managed Aquifer Recharge Scheme (Murray et al., 2018), which had been proposed in the early 2000's but not yet implemented.

As part of the Water Crisis Management Strategy, the emergency abstraction entailed the drilling of 12 additional large-diameter boreholes, up to 500 m deep (Murray et al., 2018; Scott et al., 2018), at an approximate cost of N$160 million (∼USD 10.7 million)[3]. The finalization and coming on line of the project were timed to coincide with the now extended "run-dry" date of the surface water dams (Institute for Public Policy Research, 2017). Concurrently, measures were put in place to increase production from the DPR facility from around 4.2 Mm^3/year at the start of 2015 to around 5.75 Mm^3/year, which, during the most critical periods of 2016, represented about 30% of the overall supply to Windhoek.

From the demand-side perspective, the newly established 2015 Drought Response Plan (City of Windhoek, 2015) provided guidelines for responding to the emergency situation. They were designed to maintain the health, safety, and economic vitality of the community; to avoid adverse impacts on public activity and quality of life for the community; and to consider individual customer needs as much as possible. The document

[2]NamWater's CA-Model is a computer model that simulates the hydrological water balance of the Central Area of Namibia on a monthly scale. "The CA-model performs statistical analysis to quantify the security of water supply in terms of statistical probabilities and can also be used to predict the earliest run-dry date given current water storage volumes and no future inflows into the dam (worst case scenario)" (NamWater, 2019).

[3]One Namibian dollar equals USD 0.067.

was structured to identify drought severity indicators and link them to drought response actions and program elements.

Regarding these actions, and regardless of the state of readiness, in semiarid regions with consistent patterns of recurring droughts, droughts should not be considered as disasters that warrant a crisis response. Instead, they should be seen as part of a region's condition, posing risks that can be managed with proactive policy approaches and a general preparedness for such events. In this regard, the CoW deserves commendation for putting in place options to augment its water supply long before the onset of the 2015–2017 drought. However, the eventual crisis response was based on planning done more than a decade before, meaning that the CoW were fortunate to have suitable alternatives when they were urgently needed. Often, this is not the case, leading to forced decisions, which, although they may provide short-term relief, may also be very costly and with undesirable environmental impacts. In the case of the City of Windhoek, had the augmentation schemes been implemented earlier, this would have undoubtedly provided much greater resilience to the drought.

Thus, a crisis approach can not only unduly burden the public but also threaten sustainability. Furthermore, hastily chosen solutions are unlikely to consider broader aspects such as resiliency to similar future events or the long-term effects of climate change.

Further Drought Response Actions

In past endeavors, the CoW had notable examples of successful water demand management (WDM). For example, a leak detection program put in place in the late 1990's to reduce water losses resulted in an impressive distribution system efficiency near 90% (Lafforgue and Lenouvel, 2015). In the same period, WDM through public engagement reduced overall demand by 20% (CoW Operational Data—1994–1997). However, with the onset of what turned out to be persistent dry conditions in 2012/2013, it appeared that much of the improvements in WDM gained in the mid-1990's had been lost. In fact, in a 2006 study of various aspects of WDM in the CoW, assessments clustered around "nothing done" or "not implemented," with isolated instances of "well-implemented" (Van Rensburg, 2016).

Most notable is the observation of a "neglectful attitude" among CoW WDM personnel: they did not seem concerned about the lack of adherence to WDM policies when sufficient water was available. In retrospect, the structure of the measures introduced during the 1996–1997 drought were not really sufficient to sustain "water-conscious" behavior beyond the end of that crisis, which impacted public response the next time these were needed. Therefore, as soon as the crisis passed, everyone, including the public officials who were meant to continuously drive the initiatives, resumed their past behavior. Thus, poor enforcement of WDM policies during times of sufficient water may allow the public to become accustomed to irresponsible and wasteful consumption patterns. Consumers would then need to readapt from scratch each time water becomes less available (Van Rensburg, 2016).

Within this framework of previous poor enforcement of WDM policies, the following are actual drought response actions that focused on the domestic and nondomestic sectors pursued during the drought of 2015–2017.

Domestic Sector

Communication with the public regarding water savings did not start in 2015. Due to the earlier onset of the drought as a result of the failed 2012–2013 rainy season, already in 2014, the CoW and NamWater started to urge residents to reduce their water consumption by at least 10%. However, despite this persistent communication, in 2015, the overall drop in consumption (year on year) was only 6%. As the drought intensified, the call for savings was increased to 20% in 2015 and became a mandatory 30% in 2016. This was in addition to firming up the price disincentive by introducing, in 2016, a structure whereby the allocation to each household during Severe Water Scarcity (Category E in the Drought Response Plan) dropped to 30 m^3/month, with the tariff doubling for use up to 40 m^3/month and then quadrupling above 40 m^3/month (Die Republikein, 2016). Consumption of more than 40 m^3/month also risked termination of supply, a penalty of N$2000 (∼USD130), and a formal written warning before reconnection (Lewis et al., 2019). After about 3800 households whose water consumption exceeded 40 m^3 were identified, a task team was formed to engage them (Schnegg and Bollig, 2016). "Chronic high consumers," or customers who regularly exceeded the 40 m^3 limit, were asked, in writing, to limit their water use and required to visit the city administration offices to explain their water bills and receive advice from officials on identifying and fixing possible leaks (Institute for Public Policy Research, 2017). Those who did not respond to these warnings within a certain period could then have their water disconnected and be fined for repeat transgressions (New Era, 2016).

Table 1 shows the changes in the tariff structure that were implemented during the drought. As one of the goals of public engagement was to inform consumers and obtain cooperation, rather than to penalize violators, different public engagement strategies were also put in place to garner support for water savings. For example, the #DontWashMeNAM campaign (**Figure 3**) aimed to create awareness through encouraging people to stop washing their cars (informal carwash businesses hampered demand management), an important social status symbol in Namibian society. Using art created from the dirt on unwashed windscreens, the campaign was hugely successful and well-received by the general public (The Namibian, 2016b).

Various other platforms were also adopted to engage and address the community. For example, information on the severity of the drought and on water-saving techniques was displayed in communal gathering places such as markets; drought monitors were used to distribute educational material and answer questions about the drought; and a dedicated CoW hotline, website and social media platforms were set up to allow customers to report water wastage (Die Republikein, 2015).

The effect of all the combined measures introduced at the end of 2015, when the Windhoek Drought Response Plan was unveiled, was an annualized saving of 25% in 2016 until the end of the drought (**Figure 4**).

TABLE 1 | List of the tariff structure changes implemented during the drought as part of water demand management (WDM) initiatives.

Tariffs before the 2015–2017 drought (2014)		New tariffs defined under the 2015 Drought Management Plan		Further amendment in the 2017 Water Management Plan	
0–0.2 kl/day (0–6 kl/month)	N$12.60	0–0.2 kl/day (0–6 kl/month)	N$17.77	0–0.2 kl/day (0–6 kl/month)	N$19.25
0.201–1.5 kl/day (6–45 kl/month)	N$20.93	0.201–1 kl/day (6–30 kl/month)	N$26.47	0.201–0.73 kl/day (6–22 kl/month)	N$29.91
More than 1.5 kl/day (45 kl/month)	N$38.59	1.01–1.33 kl/day (30–40 kl/month)	N$48.82	0.731–1 kl/day (22–30 kl/month)	N$55.17
		More than 1.33 kl/day (40 kl/month)	N$112.50	More than 1 kl/day (30 kl/month)	N$127.13

Source: City of Windhoek, http://www.windhoekcc.org.na/info_tariffs.php; City of Windhoek (2015, 2017b).

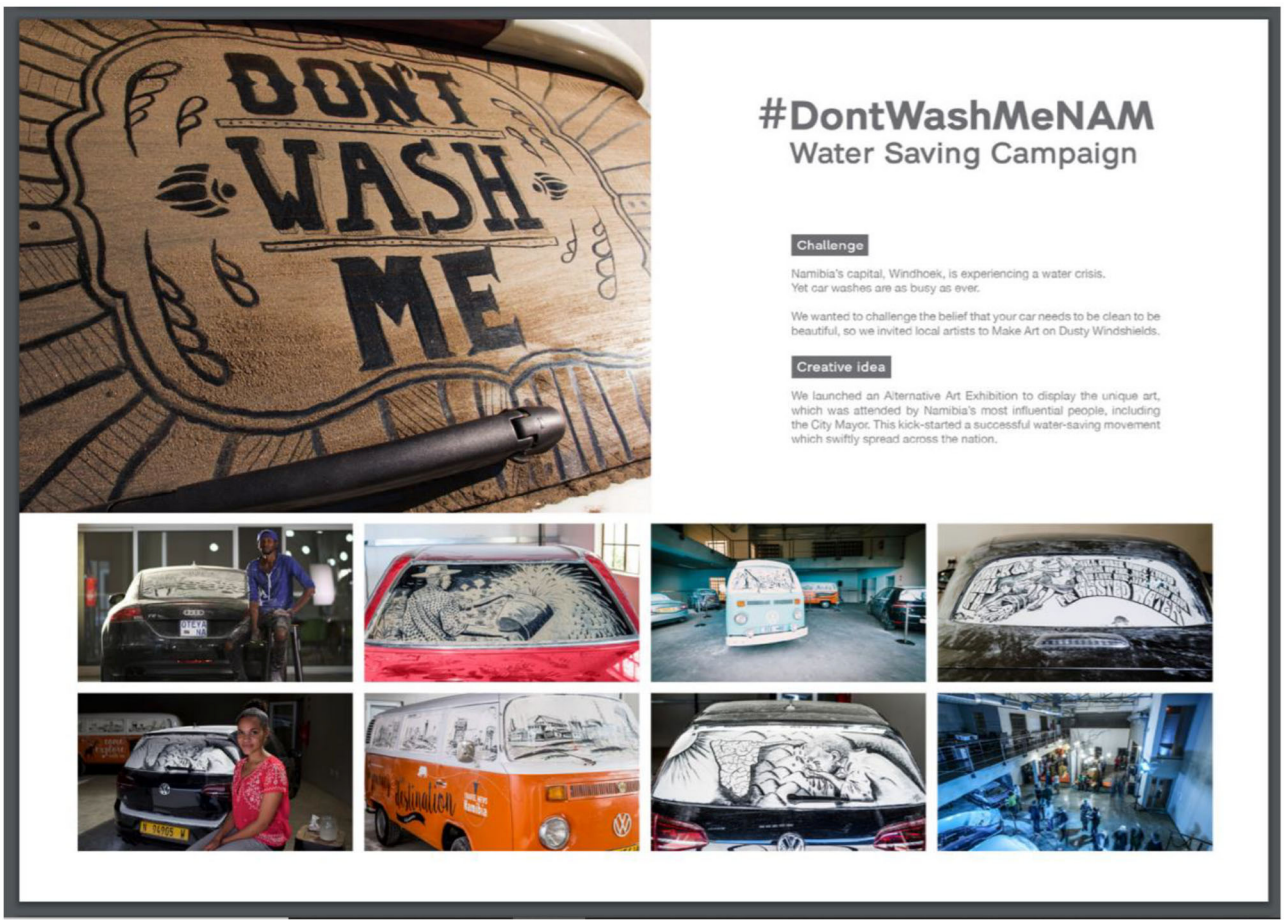

FIGURE 3 | #DontWashMeNAM campaign.

Despite their eventual success, the impact of these measures had an unacceptably long lead time, and the actual savings achieved during the whole drought period from 2015 to 2017 were only 15% or less, despite much higher targets. It is also clear that the campaign only achieved real momentum in the latter parts of the drought, and the missed opportunities early on could have had dire consequences had the drought continued beyond the start of 2017.

Furthermore, although public engagement and awareness raising was part of the CoW's strategy to reduce domestic water consumption, the overall communication strategies were, at times, inadequate and not robust enough. For example, despite the announcement that a large-scale awareness campaign would be implemented by the central government to inform residents of the crisis and urge them to reduce water consumption, the campaign was never formally launched, and materials such as posters and stickers were not formally distributed. Instead, communication was left to individual public institutions, which often produced small-scale, uncoordinated, and poorly conceptualized public education efforts. The effectiveness of

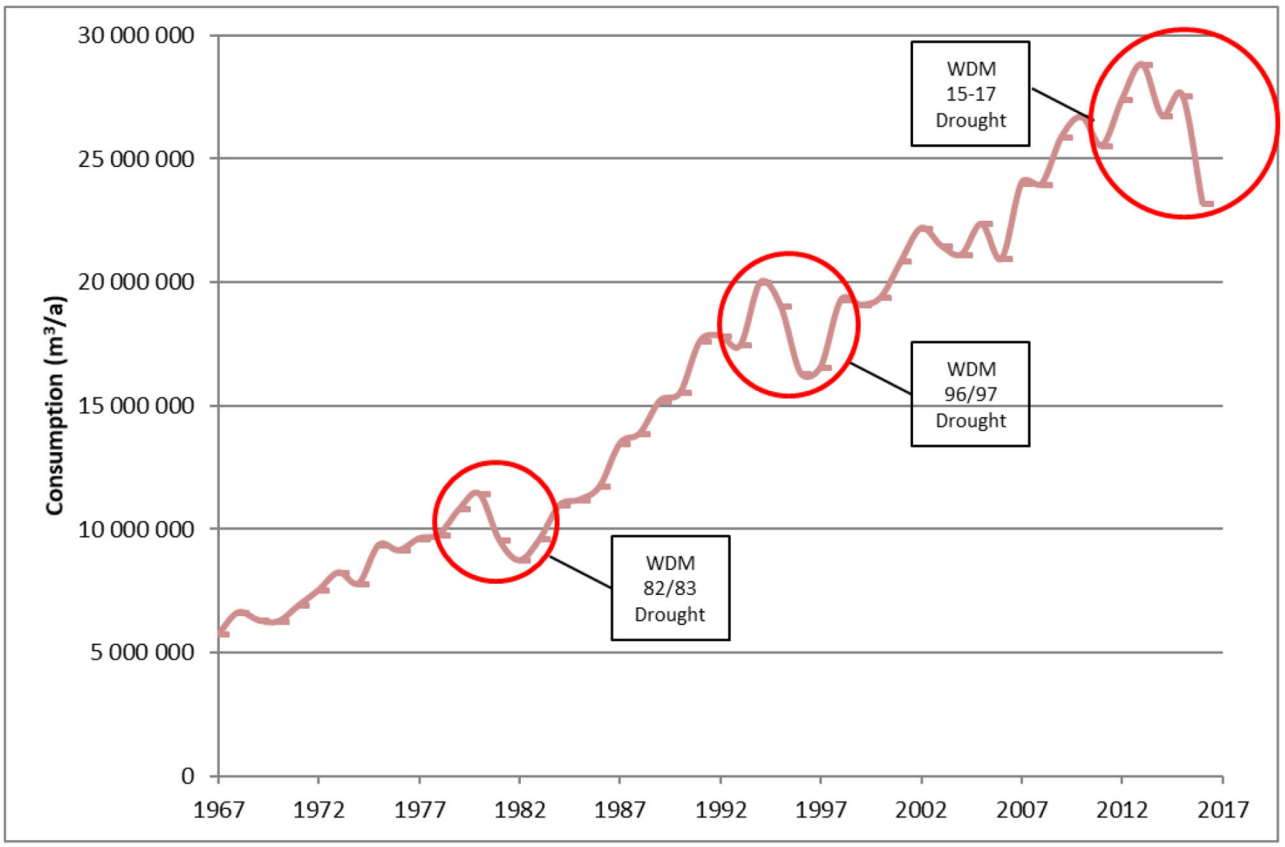

FIGURE 4 | Periodic water demand management successes in Windhoek (CoW Operational Data).

public engagement strategies was further hampered by the mixed and conflicting messages from the authorities. For instance, in September 2016, as the drought intensified, the CEO of NamWater claimed that the Windhoek aquifer had enough water to supply the city for 10–13 years. But a few weeks later, the CoW said that the reserve could last no more than 2 or 3 years (Institute for Public Policy Research, 2017).

Not directly under the control of the public authorities, but equally important, was the inaccurate and unverified reporting in the media. For example, after an announcement in April 2017 that restrictions on water use would be maintained (despite an increase in dam levels during the rainy season) because residents were still using more water than could be supplied sustainably (The Namibian, 2017), the CoW declared in May of that year that the water restrictions would be relaxed on June 1, 2017 (City of Windhoek, 2017b). Although the action by the CoW was correct, and in line with their then recently released Water Management Plan (City of Windhoek, 2017a), the conflicting messages in the media caused confusion in the public, which at that time was hyper-alert to water issues, and impeded consumer confidence in the public authorities. A consistent, uniform message from all stakeholders that aligns with the public perception of reality is critical to any successful WDM campaign, and this includes managing the media.

Engaging Industries and Public Institutions

Involving consumer sectors across the board can foster a sense of legitimacy and collaboration in saving water and increase support for drought response strategies (Turner et al., 2016). Hence, during the 2015–2017 Windhoek drought, targeted water-saving initiatives were also extended to various highly water-consuming industries. As 10% of the CoW's water supply was used by water-intensive industries at that time, and as these customers generally have effective control over consumption, the CoW was quick to engage them to help maximize water efficiency in their production processes (Institute for Public Policy Research, 2017).

For example, Namibia Breweries, the largest industrial water user in Windhoek, initiated several projects to reduce their water consumption and augment internal supply, including the drilling of boreholes in a saline aquifer to secure more of their own supply and reclaim water in their brewing and packaging plants to reduce overall consumption in line with the 30% target (LCE in joint Venture with SCE Consulting Engineers, 2019; Namibia Breweries Limited, n.d.). Namibia Dairies improved their water-use efficiency, reducing the water required to produce 1 L of product from 3.5 to 2.6 L. Measures included additional flow meters that are monitored and noted on a daily basis, water-saving devices throughout the plant and ablution facilities, and various buffer tanks, pumps, and pipes to

accumulate and redistribute the water (The Namibian, 2016c). The Meatco Windhoek abattoir attempted to go beyond the CoW's water-saving target of 30%, setting its own target of 50% (Meatco Namibia, 2016). Coca-Cola temporarily closed two of their production lines in Windhoek, stopping the production of returnable glass products and all can products, while making a commitment not to adjust prices in the short term (The Namibian, 2016a).

In general, the engagement with industries had a good degree of success. This was fostered by close cooperation between the CoW and industries, with the CoW committing to minimize the financial and economic impact of water-saving measures. However, reducing water use in a few specific sectors, namely, construction and car washing, was more challenging.

Finding a middle ground between the short-term need to sustain livelihoods and the long-term need to ensure a sustainable water supply for the CoW proved difficult, with proposed actions often met with much resistance and complaints from business owners and their employees. For example, while restrictions could be placed on the washing of cars in residential settings, it was hard to limit people's access to illegal carwash businesses, especially in the informal areas. Attempts by the CoW to fine and shut down businesses that failed to comply with the laws on business water connections and use were strongly resisted, and there were over 300 such operations in the city (Institute for Public Policy Research, 2017).

Although the Windhoek Drought Response Plan recommended that businesses delay construction until more water was available (City of Windhoek, 2015), this guidance also met strong resistance from the Construction Industry Federation, among other groups. The federation said that about 40,000 direct jobs and up to 400,000 dependents could be affected if companies stopped construction (The Guardian, 2016). Given the city's position as the economic center of the country and its high urbanization rate, any business closure or layoffs in Windhoek could reduce future investment prospects (Pendleton et al., 2014; Institute for Public Policy Research, 2017; Scott et al., 2018). Therefore, although this idea was already embedded in the CoW Drought Management Plan of 2015, it was not effectively implemented by that sector, as it was deemed of national economic necessity to ensure the viability of the construction businesses in Windhoek. The guide to water users under various levels of supply scarcity related to the WDM Response Index (WDMRI) (City of Windhoek, 2019) can be found in the **Supplementary Material**.

Even though the CoW and NamWater applied a variety of coordinated approaches to target a wide range of stakeholders, there were missed opportunities to implement best practice citizen and institutional engagement processes to encourage all-round involvement and support for the drought response strategies. In August 2016, through the Cabinet, the Ministry of Agriculture, Water, and Forestry (MAWF) formed a committee and instructed all public institutions to appoint two "water marshals" from their staff. They would hold the 2-year responsibility of educating all users on responsible water use, conducting regular water-meter readings and basic maintenance, and identifying and reporting leaks to the utilities, as well as providing broad support to the water-saving campaign (Scott et al., 2018).

This initiative, however, had limited effectiveness, as it was difficult to ensure that public institutions complied with the water-saving measures. Despite 55 water marshals being identified by the end of 2016 and receiving basic water management training, cuts in the government budget meant reduced management support and an overall lack of motivation for individuals to ensure implementation of the initiative. The budget cuts also reduced resource availability and made it difficult for public institutions to develop and build capacity to carry out necessary maintenance in cases where technical capacity was lacking, especially since they were expected to use in-house maintenance budgets for the required repairs (Save Water Namibia, 2018). Furthermore, for certain public institutions, such as schools and hospitals, disconnecting their water for breaching of rules or failure to pay their bills was difficult (Institute for Public Policy Research, 2017). This failure to effectively manage public institutions as part of the WDM strategy highlights the critical need for government at all levels to be involved in the process. Management processes by the CoW were often ignored or overruled by institutions that answered to government ministries, which were seen by many as authorities with greater standing. Despite valiant effort, the CoW could not manage to get buy-in from some ministries to ensure top–down support for its initiatives.

Government's Responses and Decision Making

As mentioned earlier, effective drought responses do not result from the mere understanding of the event. While resources should be invested in improving the accuracy of drought monitoring and early warning systems, equal or greater attention has to be paid to the improvement of drought governance structure to ensure a more effective division of responsibilities between the national and local governments. In the uncoordinated and delayed response of the national government, the Windhoek drought exposed the limitations inherent in the lack of decentralization in the country. As in many Southern African cities where the national government retains decision-making power (Makara, 2018), there was confusion over the responsibility of the various stakeholders in drought response.

A Drought Response Committee was formed by the CoW already in 2015 to monitor drought conditions and assess the effectiveness of the various strategies in the Windhoek Drought Response Plan (City of Windhoek, 2015; Scott et al., 2018). However, it was more effective in theory than practice, as there was uncertainty with respect to the authority of the committee, the reporting structure, and whether it was only an internal CoW committee or other stakeholders could be included (Institute for Public Policy Research, 2017). Although it guided some critical early management strategies to reduce water consumption and prepare emergency projects, the uncertainty around the management of the committee and the participation of external stakeholders limited real progress. The main problem,

which proved to be crucial, was that the initial committee was only represented by the CoW and did not include the other two main stakeholders: NamWater and MAWF.

It was not until mid-2016 when a briefing to the State President resulted in the formation of a Cabinet Committee on Water Supply Security (CCWSS), supported by a Technical Committee of Experts (TCE), consolidating the three critical institutional stakeholders, namely, MAWF, NamWater, and the CoW. The CCWSS/TCE immediately went to work, and building on work already done at that stage by the CoW, a three-phase emergency plan was put in place to devote attention and resources to the immediate crisis in Windhoek and the future water needs of the area (City of Windhoek, 2018; Scott et al., 2018).

Phase 1 revolved around short-term interventions and emergency projects over a period of 18 months to address the precarious water supply situation in Windhoek (Namibian Sun, 2016). This included the development of new municipal boreholes, the piping of water from the karst aquifers at Kombat and Berg Aukas to the Omatako Dam, groundwater sourcing around Karibib, and the installation of special floating pump stations to extract the remaining water from the Swakoppoort and Von Bach Dams. Phase 2 evaluated proposed measures for water security in the Central Area for the medium term (Scott et al., 2018). Phase 3 comes into the picture by looking at the region's and the country's future and long-term water requirements to ensure greater security and resilience to droughts in the long term. Despite initial difficulties with funding and the structure of the CCWSS/TCE, Phase 1 has since been completed, Phase 2 is well underway, and initial planning has started on Phase 3. This intervention was critical to the survival of Windhoek during the 2015–2017 drought, as well as the country's overall readiness for future similar events (World Meteorological Organization, 2016).

CHALLENGES AND LESSONS LEARNED

The following section outlines the most important challenges faced during the 2015–2017 drought as well as lessons learned. As mentioned earlier, these reflections are based on the first-hand knowledge and experience of the first author, who formed part of the response at the time and worked with representatives of public and private sector groups.

Climate Change and Climate Risks

Impacts of climate change and associated risks have been acknowledged by governments in Southern Africa. In the case of Namibia, the National Policy on Climate Change (Ministry of Environment and Tourism, 2010) discusses the importance of long-term planning, institutional arrangements that would be necessary for policy implementation, resource mobilization, and roles and responsibilities of the different stakeholders (public and private sectors, civil society and nongovernmental organizations, and faith and community-based organizations). However, as it is the case with most of the countries in the developing world, main limitations for implementation of plans and policies in all sectors are, among many others, lack of institutional capacity and resource mobilization. Additionally, long-term plans have to be updated regularly to reflect new climatic, socioeconomic, and environmental developments in these countries, as well as advances in the state of knowledge and technology. At present, very few countries have managed to establish such long-term plans, including the necessary budgetary considerations for proper implementation.

Specific to Namibia, climate change considerations at governmental level have very much moved to the background since the establishment of the (Ministry of Environment and Tourism, 2010) and rarely feature in discussions centered around the long-term planning of relevant infrastructure or development strategies. In spite of the critical importance, it could be speculated that issues of a more pressing nature on a day-to-day basis is the primary reason for climate change enjoying a diminished importance in the country.

However, and certainly not unique to Namibia, the unpredictability of the impacts of climate change poses a major challenge for planning purposes. Engineering water supply solutions can no longer depend on steady historical data when unprecedented climate phenomena are happening with frightening intensity or frequency. This raises questions of the usefulness of long-term strategic master planning, which has traditionally been the backbone of infrastructure development, including in the water sector. A new reality is surely setting in, and preparedness is urgently needed. The diversified supply developed for Windhoek in response to the drought was crucial in avoiding a main disaster, and it shows the value of water supply systems with sufficient redundancy to span multiyear droughts and where individual elements can counter the possible impact of climate change on a particular portion of the supply. In this regard, the planning developed for the Central Area of Namibia hinges on a multipronged approach, using surface water and groundwater, for resilience to direct climate factors.

Governance

Proper cooperation between the responsible government agencies is crucial to effectively tackle any crisis. In this case, poor or nonexistent intergovernmental relationships played a significant role in the poor initial response to the looming crisis. At that time, the various actors had a history of mutual mistrust, and, in some instances, their representatives did not clearly understand their respective roles and responsibilities. Even after the crisis was recognized, some preferred to ignore the problem rather than admit to any failure on their part, which, for the primarily government entities, might have had political implications and also affected community trust in government structures.

However, in mid-2016, there was swift progress through the establishment of the Cabinet Committee on Water Supply Security. The supporting Technical Committee of Experts was made up of representatives of the National Department of Water Affairs, the bulk supplier (NamWater) and the CoW. This created the ideal opportunity for the various stakeholders to actively integrate and coordinate planning and implementation in the water sector, enabling not only faster implementation but also better allocation of resources. This initiative not only worked

well during the crisis but has been sustained since the drought, fostering the hope that it will help to resolve future problems with timely implementation of the necessary projects.

Response Plan

As the drought began, it became clear that none of the primary responsible entities had prepared a response strategy. The region had faced similar events in the past, but the responses had been short lived, and documentation was poor or nonexistent. The CoW responded well, but drafting a coordination document and gaining the necessary authorization used up valuable time when it could least be afforded. In addition, the document, being from a single entity, was poorly received at first by other stakeholders jointly responsible for water supply and management.

Slow or Delayed Project Implementation

One of the biggest challenges, and one that arguably exacerbated the crisis, was the responsible authorities' failure to timely implement the necessary augmentation infrastructure. A 2004 NamWater study predicted that, by 2013, the water demand in the Central Area of Namibia would exceed the supply (NamWater, 2004). With the onset of the drought in 2015, the area was consuming ∼10% more than the long-term yield of available sources. The eventual failure of surface water sources (around 75% of supply), triggered by the persistent drought, was accelerated by the overabstraction of available sources, hence worsening the impact of the drought during this critical time.

Ongoing Water Resources Management

With increasing pressure on water supply globally, along with uncertainties around the impacts of climate change, no water supply authority should be without specific management tools, which are well-documented and known by all stakeholders. The value of the original Drought Response Plan (put forward by the CoW in 2015) in coordinating WDM efforts and dispersing vital information on residents' expected contributions cannot be overstated. After the end of the drought in 2017, and following the realization that demand management is not a "switch on/switch off" tool, the plan was adapted to include the necessary linkages to the supply sources; it was adjusted again in 2019 to ensure that it can effectively guide water management on a continuous basis.

Non-residential Water Demand Management

Although industry collectively represents only 10% of demand, engaging primary industrial consumers was hugely successful. Not only was the response rapid, but the focus on water consumption established water monitoring and management as standard business processes, leading to efficiency gains that will persist for the long term. Due to the uncertainty around the expected duration of the crisis and its possible recurrence, many industrial consumers preferred to focus on private augmentation, which was facilitated through special supply arrangements. At the same time, the prevailing social inequality in the city was clearly visible in the push-back from certain business sectors. Given the potential economic impact on low-earning residents, initiatives to curb water use in construction and the many informal carwash businesses were not successful, and the negative publicity around these projects undermined the overall objective of soliciting public cooperation.

Residential Water Demand Management

The loss of the gains in terms of water demand management and public awareness/participation made during the 1996–1997 drought can be blamed for the slow initial response of residential consumers to the new savings targets. Great initiatives were established during that previous drought, but then, they were abandoned for almost two decades. Had that awareness and those practices been maintained, a much stronger and prompter response to the demand management initiatives could have been expected. Even after a response was finally established, other challenges cropped up, such as the market drive toward the installation of gray water systems, which undercut the CoW's initiative to harvest wastewater for DPR supplementation.

Communication to Bring the Citizens on Board

Effectively reaching the public requires a careful balance between technical and political voices, but messages should include the right degree of technical information to enhance the public understanding of the drought. In the case of the 2015–2017 drought, efforts to communicate the severity of the drought were hampered by the inability of the various government organizations to find effective ways to engage the public. Along with the inconsistency of the messages from the various institutions, this can be considered one of the biggest failures during the drought. The fragmented and conflicting messages, along with inaccurate media reporting, inevitably led to the public questioning the credibility of information and transparency in general. Later on, the correct type of data and comprehensive explanations of the various aspects related to the crisis were key in supporting public perceptions. Citizens were more responsive when they had a clear understanding of the nature of the problem and how they could contribute to the solution.

In 2016, water savings of up to 30% (compared to previous consumption) helped extend the run-dry date of the surface water storage far enough, allowing time for alternative supply strategies to be implemented. This can be attributed to a careful "bundling" of price disincentives with restrictive targets, implemented in late 2015 and maintained through the end of the drought. This strategy, together with better communication and the distribution of critical information, helped combat the once-prevailing mentality of "as long as I can pay for it, I can have as much water as I want." Water demand management remains one of the best tools for tackling an urban water crisis, and communication is an essential part of it.

FINAL THOUGHTS

Although the CoW deserves recognition for its proactive stance through the years in securing nonconventional water sources such as the Windhoek Managed Aquifer Recharge Scheme and

DPR and for taking an early lead in responding to the drought, there should also be mechanisms to assess and quantify the cost of delayed action or inaction (Verbist et al., 2016). There is widespread criticism of the national government, the CoW, and the national utility provider for being unsupportive and passive in putting forth measures to timely address the impacts of the droughts. In this regard, the 2015–2017 Windhoek drought was an important lesson in the importance of government policies and decisions at the various levels being aligned, integrated, and consolidated in national drought responses rather than individual and uncoordinated efforts. Due to the lack of these elements, initial cooperation was critically lacking and resulted in delayed action, which was detrimental to the overall response and could have had more serious consequences.

A shift from reactive to proactive approaches does not happen overnight. One important lesson learned by the CoW is reflected in its Water Management Plan, released after the 2015–2017 drought. A substantial revision of the 2015 Drought Response Plan (V1/2015) was the Water Management Plan first released in 2017 (City of Windhoek, 2017a) and then in 2019 (City of Windhoek, 2019), which adopted a more holistic approach to WDM as an ongoing initiative instead of an emergency fallback for times of drought (LCE in joint Venture with SCE Consulting Engineers, 2019). The plan is based on scarcity severity indicators from NamWater's demand/supply modeling, using the Central Area Forecasting Model and monitoring indices, aligning the CoW's WDM response with NamWater's supply forecast on an annual basis. At the core of it is an attempt to match supply and demand on an annual basis and in the process provide constant feedback to the public on the status of water supply affecting their consumption.

As mentioned, people are more likely to save water if they understand the reasons for doing so and are constantly kept informed. This lesson from the 2015–2017 drought were very useful after the failed 2018–2019 rainy season (the second driest in over 100 years of record keeping) prompted renewed intensification of demand management. This time around, the response was immediate and the news much better received.

Finally, the story of the 2015–2017 Windhoek drought shows that feasible and effective solutions are context specific. What is common practice elsewhere could be less common on the African continent and perhaps even less in Southern Africa. Yet, the challenges are the same, if not bigger, in an environment where it may not be so easy to find readily available solutions and or a well-integrated response. Thus, the lessons learned here might be considered "ordinary" or "old news" by someone in the developed world, but they are still very relevant in Southern Africa and need to be advocated and supported to bring preparedness to the region as climate change looms.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

PR: writing submission and providing in depth information on situation analyzed. CT: writing submission and background research. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2021.602962/full#supplementary-material

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