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Don't blame the rain: Social power and the 2015–2017 drought in Cape Town

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ABSTRACT

Sociohydrology has advanced understandings of water related phenomena by conceptualizing changes in hydrological flows and risks as the result of the interplay between water and society. However, social power and the heterogeneity of human societies, which are crucial to unravel the feedback mechanisms underlying human-water systems, have not been sufficiently considered. In response, this paper proposes an interdisciplinary approach that draws on political ecology perspectives to combine sociohydrological insights with analyses of social power and of the ways in which different social groups distinctively interact with water systems. We draw on empirical evidence of Cape Town's water insecurity before and during the prolonged drought (2015–2017) that escalated into a severe water crisis, also known as Day Zero. The study integrates times series of reservoir storage and water consumption with 40 interviews and focus group discussions to firstly retrace the historical legacy of Colonial rules, Apartheid and, more recently, neoliberal policies. Within this human-water system, we show how Cape Town's political legacy has encouraged unsustainable levels of water consumption amongst the (white) elite and tolerated chronic water insecurity amongst (black) informal dwellers. This uneven geography of water insecurity is also discernible in the unequal experiences of drought and water resilience trajectories of diverse social groups across Cape Town. We conclude that accounting for social power and inequalities can advance sociohydrology by identifying those mechanisms (within society) that determine what water is secured and what human-water interactions and dynamics will be sustained over time. Furthermore, by engaging with social power, sociohydrology can play a significant role in informing policies that reduce inequalities in water access and unsustainable water use.

1. Introduction: the challenge of defining and addressing water insecurity

It is 5 pm on the 5th of February 2018 in Langa, a coloured township in Cape Town, South Africa. Kayla is about to rinse-off her hair, but not a single drop of water comes out of the shower head… She had finished the limited amount of water that her large family was allowed to consume on that day (about 350 L per residential unit[1] per day). At the same time, in Bishop Court, about 14 km South West from Langa, the Du Plessis' family is watering the garden with water from the borehole they had recently drilled.[2] Both families were experiencing a prolonged and severe drought, which resulted in a major water crisis that shocked the entire City, known as Cape Town's Day Zero. Yet, their experiences of water crisis differ. More than anecdotal, these experiences truly embody the different conditions of water access among Cape Town residents during the drought. What is more, their stories exemplify one of the questions behind this paper, which seeks to understand how and why different societal groups endure varying levels of water insecurity whilst

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[1] A residential unit in Cape Town's urban areas does not necessarily correspond to a family or a household. The residential unit (or unit) is the physical structure shared by a group of individuals that use communal basic services (i.e. water and electricity). In less privileged areas such as townships and informal settlements one residential unit can hose more than one family up to 8–15 people (McGaffin, 2018; Russell, 1998). See Section 3 for further information.

[2] All names and surnames used in the paper are fictitious in order to preserve the interviewees' anonymity, as per ethical requirements.

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experiencing the same drought.

Droughts and water insecurity overwhelmingly affect some societal groups more than others (Douglass and Miller, 2018; Loftus, 2015; Sultana, 2018; UNESCO and UNESCO i-WSSM, 2019; Zwarteveen et al., 2017). Along these lines, the World Economic and Social Survey declared that poor and marginalized groups are likely to experience the worst impacts of future water shortages (UNESCO and UNESCO i-WSSM, 2019). This becomes even more alarming in light of the increasing severity and frequency of future drought events (Van Lanen et al., 2013; Trenberth et al., 2014; Leng et al., 2015; Guerreiro et al., 2018; Schiermeier, 2018; Mishra and Singh, 2010). It is estimated that, in the next decade, about 700 million people are at risk of displacement due to water shortages (Hameeteman, 2013; Nature, 2019).

Political ecologists have long argued that the distribution of water-related risks is uneven since it is shaped by socio-political structures and dynamics related amongst others to class, religion, gender, and ethnicity (Loftus and McDonald, 2001; Bakker, 2003; Kooy and Bakker, 2008; Storm, 2009; Sultana, 2009, 2011; Swyngedouw, 1997, 1999; Zwarteveen et al., 2017; Mawani, 2019; Lutz-Ley et al., 2020).

This scholarship invited to understand water as animated by the everyday negotiations, contestations, and conciliations that take place between different actors (Anand, 2011; Truelove, 2011, 2016; Loftus, 2012; Pihljak et al., 2019; Wilson et al., 2019). In other words, water flows are continuously reshaped by unequal power relationships inherent to human societies. Nevertheless, *politics* remains all too often partial or under-elaborated both in scientific and policy contexts (Mawani, 2019; Wilson et al., 2019; Lutz-Ley et al., 2020). This also applies to contemporary policies and scientific discussions on water insecurity, which tend to neglect or inadequately account for the role that power imbalances play in shaping water systems and hydrological extremes (Loftus, 2015; Zeitoun et al., 2016).

To illustrate, Grey and Sadoff (2007) define water security as the "*availability of an acceptable quantity and quality of water for health, livelihood, ecosystems, and production coupled with an acceptable level of water-related risks to people, environment, and economies*". Following this logic, water insecurity becomes merely the consequence of hydro-climatological conditions (e.g. availability of acceptable quantity of water), rather than the outcome of particular social relations that can be transformed or addressed (Loftus, 2015).

Sociohydrology has shed new light on water related phenomena by conceptualizing changes in hydrological flows as the result of the interplay between water and society (Ertsen et al., 2014; Viglione et al., 2014; Montanari, 2015; Troy et al., 2015; Schifman et al., 2017; Di Baldassarre et al., 2018a, 2018b). Yet, these attempts of capturing human behaviour have mostly concealed socio-political processes and context-specificities that characterize every society (Evers et al., 2017; Wesselink et al., 2017). In turn, we posit that sociohydrological analyses of human-water systems undertheorize the influence of social power on hydrological flows. This, we argue, is problematic for several reasons. First, it conceals the political, economic, and social relations that make some societal groups significantly more able to control and alter the spatial and temporal distribution of water resources. Secondly, every social group has different capacities and resources to recover from, and adapt to, extreme hydrological events (Fothergill et al., 1999; Wisner et al., 2004; Adger, 2003). To illustrate, a drought will engender different resilience trajectories that cannot be generalized nor merged as a common societal response. In turn, each trajectory will diversely affect or interact with water systems. By glossing over the power structures that define society, there is a risk to promote water policies that are inadequate to address water related challenges (Wheater and Gober, 2015) or perpetuate social and environmental injustices (Ikeme, 2003; Zwarteveen and Boelens, 2014; Loftus, 2015). Thus, it is key to acknowledge the existence of plural, and at times conflicting, interests within societies as well as their implications for human-water systems.

In response, this paper considers water insecurity and hydrological extremes as phenomena engendered by the complex interactions *within* society and between society and hydrological flows. To analyse this interplay, the article engages sociohydrological perspectives with political ecology. We draw on empirical work on the Cape Town's 2015–2017 drought to examine how different societal groups, distinctively interact and coevolve with the human-water system. To do so, we combined about 40 semi-structured interviews and focus group discussions undertaken between May 2019 and March 2020 in Cape Town (Annex A, Supplementary Material) with secondary data from recent literature and the City of Cape Town's data portal. The semi-structured interviews offered participants the opportunity to explore issues they perceive as important (Longhurst, 2003). Through focus group discussions, a group of selected individuals explored particular issues that are compelling for their specific social group (Secor, 2010). The interviewees selected belong to diverse societal groups and socio-economic sectors to represent different – convergent and divergent – societal interests, unequal degree and forms of power and diverse experiences of water security across Cape Town. The questions mostly concern the everyday water use as well as the domestic experiences and copying strategies during the drought (Annex B, Supplementary Material). This in-depth qualitative analysis is combined and triangulated with quantitative data that set out the sociohydrological examinations of this study (i.e. time series of rainfall, annually-averaged reservoir storage per inhabitant, human population and annually-averaged daily water consumption). As a proof of concept, Annex C (Supplementary Material) combines the methods with most of the primary and secondary data used to elaborate the main argumentations.

Specifically, we examine Cape Town's domestic water access and water consumption both before and during the drought. In doing so we question the extent to which water insecurity can be solely blamed on the latest drought which was indeed "very rare and severe" (Wolski, 2018). The paper exposes the relation between water insecurity and urban development under Colonial rules, Apartheid and, more recently, neoliberal policies. While retracing the hydrological and political *legacy* of the City, we expose the power relations that produce uneven levels of water security in Cape Town, thereby enriching examinations of the current sociohydrological drought and its uneven impacts. Finally, the paper delineates the different drought-resilience trajectories of Cape Town's diverse urban areas, which represent multiple and distinctive human feedbacks to the local water system.

Based on this work, we conclude that societal differences or power imbalances are more effective in explaining human interactions with water systems, relative to the average societal response. This is where the political ecology's contribution to sociohydrology lies. Our argument insinuates that power, which often manifests in economic, cultural, and political advantages, determines the way in which certain societal groups are better placed to influence water systems, at the detriment of sociohydrological inequalities and unsustainable water use.

2. Water (in)security: engaging sociohydrology with political ecology

Water insecurity is concerned with challenges related to water resources availability and the multiple trade-offs between growing urban demands, social justice concerns, and environmental needs (Bakker, 2012; UN-Water, 2013; Wheater and Gober, 2015). Prevailing scientific approaches that tackle water insecurity tend to simplify socio-economic patterns and/or disregard human responses that influence water availability and use (Bakker, 2012; Zeitoun et al., 2016). However functional for scientific purposes, these simplifications can perpetuate inequality and/or result in unintended consequences for both environment and society (Srinivasan, 2015; Di Baldassarre et al., 2019; Tiwale et al., 2018). In the context of human-drought interactions, unintended consequences are sociohydrological phenomena like supply–demand cycles and reservoir effects. The *supply–demand cycle* (Kallis, 2010) describes instances where water-supply infrastructure enables urban, industrial, and agricultural expansions, which in turn increases water demand and thus pressure on the available water resources. As a result, this phenomenon gradually off-sets the benefits that were initially foreseen, and makes the societal system more susceptible to water insecurity when droughts occur. Another sociohydrological phenomenon often associated with water supply expansion projects is known as the *reservoir effect* (Di Baldassarre et al., 2018a, 2018b). It occurs when reservoirs simultaneously secure water availability and increase the community's dependence on water infrastructure, resulting in higher vulnerability to, and impacts from, future droughts or water shortages. Similar unintended consequences of water infrastructure have also been described by scholars as *fixes that backfire* (Gohari et al., 2013).

The study of these phenomena is central to sociohydrology scholarship, which argues that water and human systems change interdependently and co-evolve over time (Sivapalan et al., 2014; Ertsen et al., 2014; Viglione et al., 2014; Montanari, 2015; Troy et al., 2015; Schifman et al., 2017; Di Baldassarre et al., 2018a, 2018b). Hence, sociohydrological studies do not only connect the hydrological and social processes that produce extreme or undesirable conditions, but also explicitly account for the temporal dimension of this interaction (Srinivasan et al., 2017). The time dimension explains phenomena like water insecurity as *legacy* of the past as well as the result of continuous feedbacks between hydrological, technical, and social systems (Di Baldassarre et al., 2019; Srinivasan et al., 2017; Srinivasan, 2015). Using a similar hypothesis, Srinivasan (2015) analysed the urban water systems of Chennai, India, and showed how changes in past decisions would result in different feedbacks on Chennai's sociohydrological system and, consequently, in different levels of water insecurity. In this case, different sociohydrological trajectories are contingent upon Government's decisions on water infrastructure and water tariffs. Changes in the initial level of water storage (high or low) and in the type of water tariffs (flat or volumetric) influenced the households' ability to access water and water secure themselves.

To date, sociohydrology has advanced understanding of the multiple ways in which humans have influenced the occurrence and impacts of hydrological extremes. Yet, with few exceptions (e.g. Srinivasan, 2015; Garcia et al., 2016, 2019), this scholarship does not explicitly consider the power relations that define society and the agency of different societal groups and individuals (Wesselink et al., 2017; Evers et al., 2017). Sanderson (2018) has recently highlighted how different individuals or societal groups have more or less power to negotiate their access to water depending on their position within society. To illustrate, when Lilongwe, the capital of Malawi, experienced water shortages, field engineers and water utility managers have often faced political pressures to concentrate water supply in high income residential areas, commercial districts and city centre, thereby leaving lower income neighbourhoods poorly served (Alda-Vidal et al., 2018). Furthermore, sociohydrological interpretations of society do not purposely account for the rationale of societal interventions or driving mechanisms of human-water system dynamics (Evers et al., 2017). For instance, economic growth or industrialization are not seen as the result of prevailing policies put forward by, and in the interest of, the most powerful societal groups. Overlooking power imbalances and heterogeneity within society, sociohydrology risks ignoring some of the factors that engender water insecurity. This might also lead to technical solutions that are likely to reproduce existing inequalities and leave some societal groups more vulnerable and water insecure than others (Ikeme, 2003; Tiwale et al., 2018; Mawani, 2019; Wilson et al., 2019).

To better understand the interactions between human and water systems, we draw on political ecology's perspectives on water access and distribution which in our view are able to deepen sociohydrological interpretation of society. As sociohydrology, political ecology is concerned with examinations of water and society relations, but focuses on society and its relationships with the environment (Perreault et al., 2015). Political ecology's studies on water analyse how power determines which actors have control over, and decide upon, water resources development, infrastructure, and water distribution (Swyngedouw, 1997, 1999; Ekers and Loftus, 2008; Zwarteveen et al., 2017; Rusca et al., 2018; Loftus et al., 2019; Wilson et al., 2019). Other studies also seek to understand the socio-political processes, such as decision-making, policy-making, ideological or governance shifts, which cause social inequalities and environmental degradation (Pelling, 1999; Leff, 2015; Loftus, 2015; Perreault et al., 2015). Along these lines, past critical studies have examined the relationship between flood and drought, and processes of governance and uneven development (Pelling, 1999; Bankoff, 2003; Verchick, 2012; Douglass and Miller, 2018; Williamson, 2018). Pelling (1999) for instance, showed how different experiences of flood in Urban Guyana were mostly a consequence of the global liberalization and privatization policies which privileged economic growth at the expense of societal and environmental justice (Pelling, 1999). On a similar note, Mustafa (2005) and Collins (2010) illustrate how the distribution of uneven vulnerabilities to hydrological extremes strongly relates to existing power imbalances and societal inequalities. For them, it is often a process of marginalization and/or dispossession (vs facilitation and/or accumulation) that cause uneven experiences of the same hazard. Through these analyses – which reveal that water and society coevolve *in a political space* – political ecology sheds light on the politics that ignite and/or reshape human-water interactions. More precisely, these examinations expose the actors and processes that bring about distinct human feedbacks to water systems.

Hence, as we show in the empirical analysis below, coupling sociohydrology with political ecology enables more comprehensive understandings of the temporal and spatial dimensions of water insecurity and the politics thereof. On the one hand, sociohydrology enables the analysis of the interplays between social, technical, and hydrological processes that over time have engendered Cape Town water insecurity. On the other hand, political ecology sheds light on the political processes that have engendered (unequal) human-water system dynamics and produced uneven geographies of water insecurity. Importantly, our study describes Cape Town water insecurity before and during the 2015–17 drought in order to understand to what extent the production of water insecurity relates to the occurrence of drought conditions.

3. The legacy of Cape Town' human-water system

The legacy of Cape Town's human-water system is one of segregation, inequality and uneven water access, reflected in unsustainable consumption practices amongst the city elite and chronic water insecurity experienced by informal dwellers. In this section, we discuss how the historical development of the city from colonial times to Apartheid and the more recent neoliberal reforms, promoted an economic growth model that produced an uneven water system and privileged some societal groups at the expense of social and environmental justice. In particular, we show that throughout the different regimes and governance shifts that characterise Cape Town's history, policies have continued to privilege large-scale investments in, and for the development of, the white areas. Last, we show how these developments inevitably intersect with sociohydrological processes which have been described as *supply–demand cycles* and *reservoir effects* (e.g. Di Baldassarre et al., 2018a, 2018b).

During colonial times (1652–1948) the City was an international trading post welcoming mostly Dutch and British merchants to extract the colony's riches and export them to Europe. Cape Town's infrastructure did benefit from the prosperity of the Colony, but public works and urban development were concentrated in the city centre where the properties of elite merchants were located (Miraftab, 2012).

Amid Apartheid (1948–1994) Cape Town became an explicitly race-based segregated city: with black and coloured people isolated in townships, and white elite controlling the central areas. Also in those days, government investments in infrastructure and services, mostly benefited the white elite (McDonald, 2012). In terms of water access this meant that the elite received high quality and highly subsidised water services through in-house connections, while black areas were poorly serviced by rudimentary water infrastructure such as yard taps or public standpipes (Smith and Hanson, 2003).

With the end of Apartheid (1994-today), Cape Town underwent significant structural changes to meet global demands (Lemanski, 2007). In fact, the post-apartheid landscape was marked by the rise of neoliberal ideals and restructuring (Lemanski, 2007; Miraftab, 2007; McDonald, 2012). The neoliberal ideology assumes that competitive and unregulated markets (i.e. free from state interference), as well as commercialisation or privatisation of services, are the most effective mechanisms to achieve economic growth and deliver services (Brenner and Theodore, 2002). In Cape Town, the neoliberal shift materialized in policies aimed at attracting transnational capital and fostering economic growth (McDonald, 2012). In turn, Cape Town's central districts became the target of massive private investments and new developments, which were also encouraged by the high-consumption lifestyle of the City's elite (Lemanski, 2007; Miraftab, 2007; McDonald, 2012). To explain it in Miraftab's (2007, p. 620) words, the downtown real estate became what land was for the colonizers: "*modern gold mines*". Over time, these policies created a multi-layered system that tolerates world class services in privileged areas and substandard services in unsafe and crumbling spaces (McDonald, 2012). Today, Cape Town's metropolitan area includes over 40 towns with approximately 4 Million inhabitants. The city gradually became a popular tourist destination, and an attraction for international businesses and investors. Meanwhile, on the outskirts, informal settlements and desperate poverty continues to sprawl (Lemanski, 2007; McDonald and Smith, 2004; McDonald, 2012).

Cape Town's socio-economic index (Fig. 1a) indicates that both the city elite and the upper middle class, mostly live in the western city suburbs enjoying 'very good' socioeconomic conditions (COCT, 2014). In comparison, the lower middle class has a lower socio-economic index (good or average) and cannot benefit from the same privileges i.e. having more than one car, large gardens or swimming pools. Poor areas remain largely concentrated in the South-East of the city, which registers the highest population density (COCT, 2014). Low-income areas can be further distinguished between formal townships and informal settlements depending on their income level, type of housing and access to basic services. During Apartheid, townships were reserved for non-white people, namely Asian, black and coloured, and were mostly concentrated in the (eastern) periphery of the City (McDonald, 2012). Today these neighbourhoods continue to be overcrowded and maintain the same racial composition. They have an average or needy socio-economic index and usually access to basic services (such as water, sewage and electricity). Yet, it is quite common for more than one household to share the same unit in order to split rent and utilities among 8 to 15 people (COCT, 2014). In terms of water access, this implies that, despite having access to basic services, many households in townships might not reach the minimum of 25 L per person per day promised by national water policies (Peters and Oldfield, 2005). Informal settlements are characterised by households living in informal dwellings and overcrowded conditions.[3] According to the socio-economic index, these areas include the most disadvantaged households, where residents lack adequate basic services and suffer from high unemployment rates and rampant crime. Informal dwellers do not usually have piped water in their premises and access water through common standpipes (COCT, 2014). The average daily water consumption per household within informal settlements is 40 L per unit per day (where each unit can often host 8 to 15 persons).

This striking contrast across urban spaces led Lemanski (2007) to describe Cape Town as a polarized city. The spatial and social polarization is visibly reflected in its water supply system both in terms of access and consumption, as we discuss later in this section. In fact, depending on the suburb and, therefore, on the socio-economic status, households can have piped water inside their premises, piped water within or further than 200 m from their house (Fig. 1b). Most of the time, people that have no water within their premises, have lower levels of access to safe water (Currie et al., 2017). However, even with piped water in their premises the large households in the townships struggle to have enough water for basic needs (Peters and Oldfield, 2005). Consequently, we could argue that the socio-political processes which shaped Cape Town's urban space from colonial to post-apartheid eras, whilst discriminating water access, also engendered different levels of water insecurity across the city.

Since Apartheid, Cape Town authorities have privileged the expansion of water supply through large infrastructure as water management strategy (McDonald, 2012). As a result, Capetonians today depend almost entirely on the Western Cape Water Supply System, a raw water-storage system of six major dams that constitute more than 95% of the total system capacity (900×10^6 m^3) (COCT, 2018). Yet, this strategy mostly benefitted those Capetonians who could afford and were able to use more water. On the contrary, the government investments in large dams and reservoirs were not able to improve water access or the consumption amongst the most disadvantaged groups (McDonald, 2012; Jaglin, 2008; Smith, 2001). The reason for this failure is the fact that local authorities did not directly address urban inequalities (McDonald and Smith, 2004; Lemanski, 2007; Miraftab, 2007; McDonald, 2012; McFarlane, 2018). In fact, despite progressive policies to ensure universal access to water and basic services,[4] townships and informal dwellers did not improve their precarious living conditions nor their access to water services (Smith, 2001; Jaglin, 2008; McDonald, 2012).

Fig. 2a shows that, with the completion of Cape Town Water Supply System, reservoir storage increased significantly at the end of the 1970s reaching an average water supply of over 1200 L per capita per day. Securing water resources contributed to enable population growth in Cape Town (Fig. 2b). Yet, this also allowed the most privileged Capetonians to reach unsustainable levels of daily water consumption (Fig. 2c). This increased the pressure on the available water resources (Currie et al., 2017; Koopman and de Buys, 2017; COCT, 2018) and led to a severe water crisis when a prolonged drought eventually occurred in the period 2015–2017 (Fig. 2d). Whilst the reduced per capita reservoir capacity can be interpreted as a manifestation of a *supply–demand cycle* (Kallis, 2010; Di Baldassarre et al., 2018a, 2018b). Garcia et al. (2020) relate Capetonians increased vulnerability to water shortages to a *reservoir effect* due to heavy reliance on large water infrastructure, which attenuated hydrological variability (intended effect), but also delayed response to the 2015–17 drought (unintended consequence). These sociohydrological explanations shed light on the inefficiencies of water-supply management policies, yet they do make allowance for society's heterogeneity and the highly unequal levels of water consumption in Cape Town metropolitan area (Fig. 2c).

Through this case study, we show how an engagement with political ecology and, in particular, accounting for social inequalities can advance conceptualisations of the *supply–demand cycle* and *reservoir effect*. This integrated understanding acknowledges the diverse human interactions with water systems. In addition, it also recognizes the driving mechanisms underlying human-water systems which in Cape Town case very much relate to the high-consumption lifestyle of the City's white elite.

As disclosed by our qualitative analysis, most of the water from the Cape Town Water Supply System was supplied to sustain the "*ridiculous*" (SSIM-02) high standards of living of the city elite and upper middle classes. Whilst the latter could maintain high levels of water use,

[3] About 25% of Cape Town's population lives in informal dwellings. In fact, the metropolitan area counts about 320,000 informal residential units (McGaffin, 2018).

[4] In the years 2000 the National Department of Water Affairs introduced a Free Basic Water policy which guarantees to every household a basic supply of 6000 L of free potable water every month within 200 m of a person's home (Peters and Oldfield, 2005)

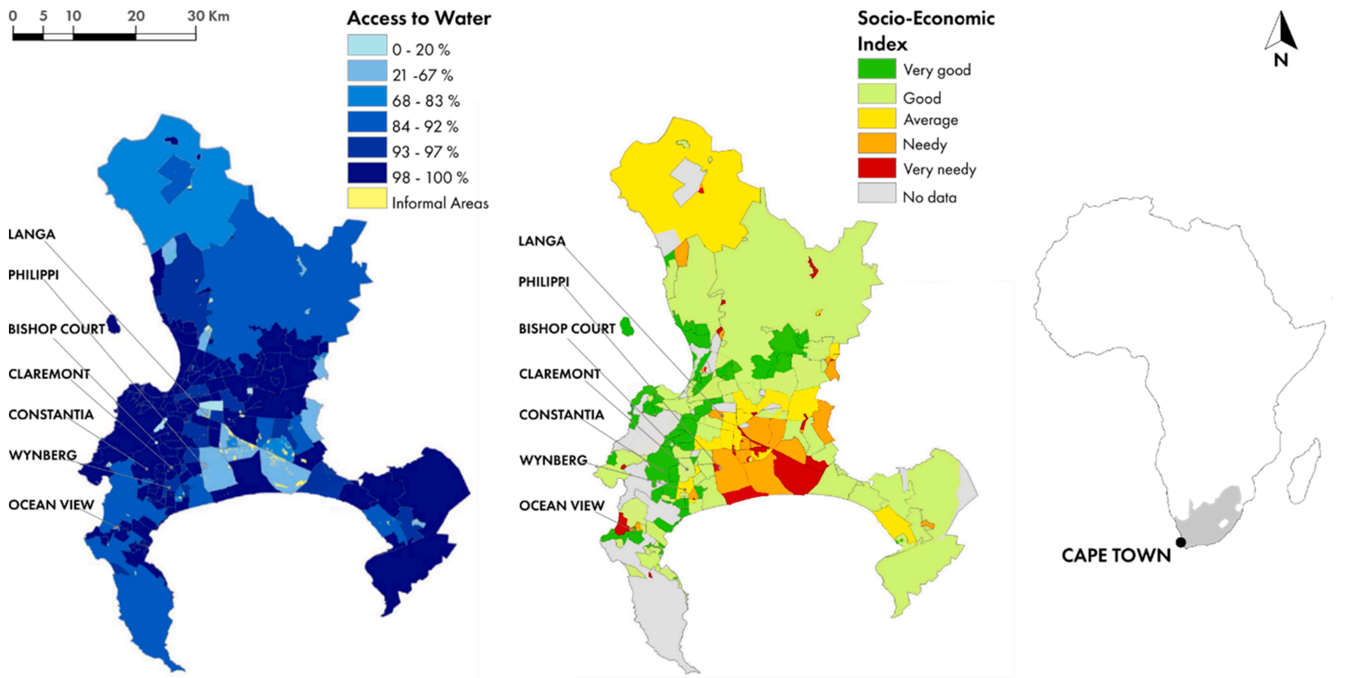

Fig. 1. Spatial representation of the Socio-Economic Index (SEI) across Cape Town Metropolitan area (left panel) and water access levels across Cape Town's metropolitan area (right panel). The SEI, developed by the City of Cape Town, is a qualitative assessment of a neighbourhood which reflects a combination of four separate variables: household services, education, housing and economic level. According to the SEI, elite and upper middle classes are citizens who benefit of "very good" socioeconomic conditions. Lower middle classes have "good" or "average" socio-economic index, whereas township dwellers and informal settlers are mostly "very needy" and "needy" citizens. The level of water access is estimated by the percentage of households with access to water in their premises, as defined by a tap inside the dwelling and/or within a backyard. Adapted from: Currie et al. (2017) and COCT (2014).

inhabitants of informal dwellings at the urban fringes did not have running water in their premises (Viljoen, 2016; COCT, 2018). Data on water consumption for residential properties in 2015,[5] reveal a starkly uneven picture across different suburbs (Fig. 2c). We found that the elite living in Constantia or Bishop Court, for instance, consumed between 774 and 8560 L per capita per day, whilst Claremont, an upper middle-class neighbourhood, averaged about 462 L per capita per day. On the contrary, the lower middle-class neighbourhood and the township averaged between 350 and 90 L per capita per day. Lastly, in informal settlements like Philippi, water consumption approximates to 10 L per capita per day (Viljoen, 2016; COCT, 2020).

Overall whilst informal settlements were using about 4% of the total water available, the upper and middle class, accounted for the 70 per cent of domestic water consumption (Robins, 2019). To further validate our findings, we refer to McDonald's (2012) analysis, which reveals that already a decade ago, more than half of the city's water (about 400 million litres per day) was supplied to the more affluent suburbs, with 35% going to their gardens, and another 10 million litres per day to the 68.000 swimming pools in the city. Based on this unequal consumption we can assume that the *supply–demand cycle* and the *reservoir effect* in Cape Town have not been generated by all societal groups in the same extent. To use Robins' (2019, p. 14) words, our work suggests that "*it was mostly the (upper) classes, with their washing machines, flush toilets, lawns and swimming pools, who were the problem*".

Political ecologists have often described the unsustainable water consumption from the city's upper classes as a form of accumulation achieved by concentrating water resources in the hands of the city elite while dispossessing both the environment and the marginalized population (Swyngedouw, 2005; Harvey, 2006; Bakker, 2007; Ahlers, 2010).

In this light, the uneven consumption of water in Cape Town both reflects and results from the uneven development of the City. Accordingly, our study reveals another story of accumulation by dispossession, with the city elite increasingly adopting unsustainable water consumption practices and the rest of the population suffering from chronic water insecurity. On the one hand, sociohydrology has explained how the complex system of dams and water reservoirs while making water available, might have also enabled unsustainable water consumption. On the other hand, through a political ecology analysis, this work has identified and exposed the political interests that have generated and perpetuated unequal level of water consumption across Cape Town Metropolitan Area. These powerful interests, we found, are crucial in leading those political processes that have produced uneven geographies of water insecurities. In light of these findings, it becomes clear that by disregarding the political dimension, we risk preserving those political forces which engender unsustainable sociohydrological changes to the detriment of the environment and marginalized societal groups.

In the next section, we aim to understand if the legacy of the city has important implications in the way the 2015–17 drought was perceived and experienced. We first explain what happened in the Cape Town metropolitan area when (after the drought onset) the six major dams were about to run dry. Then we explore whether (and how) the uneven geography of water access and uneven consumption echoes with different experiences of drought across the city.

4. Whose day zero during the Cape Town water crisis?

4.1. Towards the crisis

Most literature defines Cape Town's 2015–2017 drought as the rarest and most severe since last century (Conradie, 2018; Otto et al., 2018; Wolski, 2018); others consider it the longest that the Western Cape has ever experienced (Botai et al., 2017). The bottom panel of Fig. 2 shows that the region received less water than it was used to for three

[5] Data were retrieved from the City of Cape Town Data Portal (COCT, 2020) and reveal the daily water consumption across Cape Town different neighbourhoods in 2015 (the unit of measurement is Litres per capita per day).

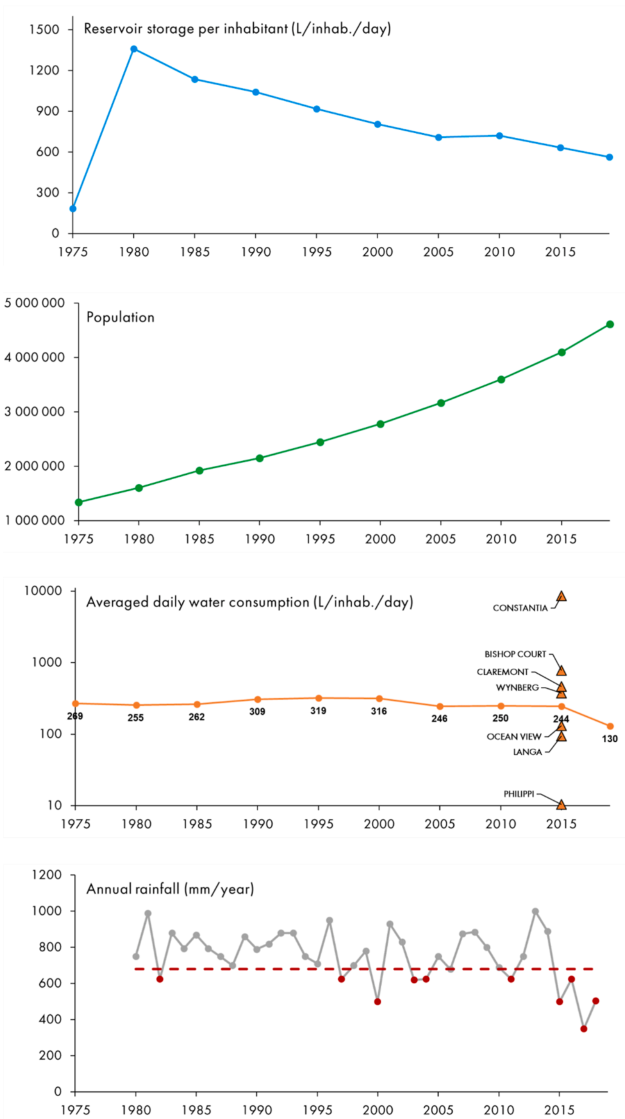

Fig. 2. Time series in Cape Town: (a) annually-averaged reservoir storage per inhabitant (L/inhab./day), (b) human population, (c) annually-averaged daily water consumption (L/inhab./day), and (d) annual rainfall (mm/year). Drought years are shown in red and identified as annual rainfall below a threshold (red dotted line). Fig. 2c includes also the breakdown of the annually-averaged daily water consumption for 7 different neighbourhoods, respectively Constantia and Bishop Court which represent the city elite; Claremont and Wynberg which exemplify respectively upper and lower middle class; Ocean View and Langa are two townships and finally Philippi, which is mostly an informal area. Data sources: Koopman and de Buys (2017), Wolski (2018) and COCT (2020). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

consecutive years, with a substantial drop in precipitation in the period 2015–2017 (Botai et al., 2017; Conradie, 2018; Winter, 2018; Wolski, 2018). The precipitation deficit caused a sharp reduction of the available water (Otto et al., 2018) and toward the end of the meteorological drought the water level of the six major dams supplying the City reached 22.8% of their storage capacity, which translated to 12.3% of usable water (Botai et al., 2017).

This prolonged and severe meteorological drought induced an extreme hydrological drought. Its impacts were so dire mostly because of the high water demand that some of the city's neighbourhoods had become accustomed to (Koopman and de Buys, 2017). In other words, the unsustainable consumption of water, especially in upper and middle class suburbs, exacerbated the negative effects of the hydrological drought as well as the perceptions and experiences of the drought across the City.

When Cape Town's major dams reached the dangerous threshold of 22% of the storage level on January 2018, water authorities intensified their control on water allocation, raised the price of water, and imposed restrictions on water consumption levels. In a few cases, city officers also installed water metering devices to further limit domestic consumption. Besides this, the city of Cape Town implemented an extensive and unrelenting communication campaign which spread fear and anxiety amongst inhabitants (Walton, 2018). The so-called Day Zero campaign[6] shifted the burden of accountability from the city to the citizens, who suddenly became responsible for drastically reducing their consumption and avoid Day Zero. The Mayor Patricia de Lille warned the citizens that: "*if they would not change their behaviour, the chance of reaching Day Zero on April 2018 will be very likely*" (in Deklerk, 2018). As of January 2018, all Cape Town residents (except the informal dwellers) were to consume a maximum of 50 L per person per day (COCT, 2018). By then, the water crisis had already shaken the City and reached worldwide attention. Most of this attention was due to the fact that the drought seemingly affected a large middle-class population for the first time in history (SSIM-02).

In the next section, we examine the geography of water insecurity in Cape Town after the drought onset. By witness of interviewees and through secondary data, we hereby retrace which factors produced the different experiences of water insecurity across the metropolitan area during the latest drought.

4.2. Perception of domestic water insecurities

Day Zero was unevenly experienced amongst Cape Town citizens (Millington and Scheba, 2020). According to the local authorities interviewed, it was the upper and middle class who were heavily hit by the water crisis (SSIG-01). International media and local authorities emphasise that the crisis affected the upper and middle class population whose lifestyle came under serious threat (Baker, 2018; SSIM-02).

Upper and middle classes were indeed the primary target of the City of Cape Town during the Day Zero campaign. It was mostly in these suburbs where the Municipality performed its relentless Day Zero campaign, using various media-communication tools, including radio messages, door to door outreach, and informative boards. Only then, people became aware of their wasteful practices and implemented water saving strategies in order to comply with the City's restrictions. Apparently, before the drought water never represented a problem for those Capetonians: people "*did not care*" (SSINGO-03) and they would "*just leave the tap open*" (SSICS-02).

The day zero campaign foresaw restrictions in water use up to 50 L per person per day or 350 L per unit per day everywhere in the City (except in the informal settlements). In addition to that, water authorities decided to impose increased tariffs and fines for illicit usages. When the water tariff was increased, those who were used to consume higher amounts of water, had to drastically reduce their water use (SSIG-01). Very large consumers (>35 kilolitres), went from paying about 70 Rands per kilolitre, to 900 Rands per kilolitre, or else more than 30.000 Rands each water bill (COCT, 2018). In a few households, the City officers installed water metering devices to control and stop unsustainable water uses. These devices record the water consumed in each unit and stop water provision once the maximum permitted amount of water (i.e. 350

[6] The Day Zero Campaign is a communication strategy adopted by Cape Town's Authorities to prevent the occurrence of water shortages across the City, "Day Zero" would herald the start of Level 7 water restrictions, when municipal water supplies would largely be switched off and residents would have to queue for their daily ration of water, making the City of Cape Town the first major city in the world to potentially run out of water. See also (COCT, 2018).

L per unit per day) is reached.

Overall, these Day Zero measures prevented the upper and middle class from maintaining their previous consumption standards. Specifically, most of the wealthier families could not water their gardens, fill up their swimming pools, wash their cars, or bath and shower as regularly as they did before the drought.

However, the idea that the upper and middle classes were most affected by the drought is most probably based on their perceptions and reactions to the crisis, rather than on actual experiences of water insecurity.

4.3. Domestic water insecurities and everyday coping strategies

In practice, during the drought the city's upper and middle class never remained without water and never suffered any drastic shortage (SSICS-01). Moreover, to overcome the City's restrictions upper and middle class' households adopted a number of coping strategies (SSINGO-01). Our qualitative analysis reveals that most of those families bought bottled water, purchased rainwater tanks, and/or used spring water collected outside the town (SSIM-01). If wealthier and located close to an aquifer, some upper and middle class households drilled a borehole to replace or integrate municipal water supply with groundwater, for which no restrictions were applied. In sum, those who had the financial resources to do so, went off-the-grid (i.e. using water sources alternative to the water provided by the City), quickly bypassing restrictions and overcoming shortages. As a result, most of these households were able to alleviate their burden and overcome the fear of "*becoming like them* – i.e. the informal settlement dwellers" (SSIM-03).

This aptly illustrates how the social and economic advantages provided upper and middle class residents with 'room to manoeuvre' to cope with emerging water insecurity. Furthermore, the development of alternative water sources increased their resilience to future droughts and/or municipal water shortages. We thus contend that a privileged socio-economic status allowed the upper classes to improve their level of water security and to become more water-secure than they were before the crisis and, ultimately, to exert more pressure on the local water system. As WWF (2020) recently revealed "*most of the reduction of water uses achieved by Capetonians came as a result of the residents aggressively pursuing alternative water sources and most notably groundwater*". Only in the Newland upmarket suburb, their census found out that more than 100 wells were not included in the government database and that 50% of those boreholes have been drilled between 2017 and 2019 (WWF, 2020).

The experience of drought in the townships was markedly different. Here, most of the dwellings only have access to basic water services. Since 2000, the Free Basic Water policy has ensured the first 6000 L of water per month. Yet, as this amount was to be shared among a large number of dwellers occupying a housing unit, the water available was often insufficient. In general, before the drought "*water was never free but [the price] was very very little*" (FGDCTC-01). When the water crisis escalated, one of the first decisions of the City was to suspend the Free Basic Water policy and increase the water tariff which was not always affordable for townships residents. As a matter of fact, the new tariff was "*a shock*" (FGDCTC-02):

> "Some of us is not privileged to have money every day to go buy water and then you need to manage your washing, water for your toilet, […] or to clean the yard and everything. So, it was a lot of strain on us also. Some of us do not work, there is no income every day to go buy water and you need to travel to go buy water… Is not that you can just walk around the corner and go buy some water." (FGDCTC-01).

Along with the increase in tariff Cape Town's water authorities also intensified the installation of water metering devices to restrict the water usages and avoid unpaid bills. In the townships these devices were peculiarly labelled *weapons of mass destruction* by dwellers, as they perceived them as a tool to drastically cut their water consumption (FGDCTC-02). In principle, formal townships were subject to the same water restrictions as the upper and middle class (a maximum of 50 L per persons per day and 350 L per unit per day, respectively). However, these restrictions were calculated on average residential units of 6–7 people per unit, whilst township' units often host about 8 to 15 (as mentioned in section 3). Therefore, in practice, townships households were often restricted to much less than 50 L per person per day.

Coping with water use restrictions and increased water tariff was challenging in the townships and those dwellers which could not afford alternative water sources, all too often ran out of water. Some users in Delft declared to have experienced a water shortage for two to four days in a row (FGDCTC-01). Some women were forced to stop the daily housecleaning because the water metering device interrupted the provision in the middle of the morning. Hence, they could not wash their clothes, clean the house nor cook the family meals (FGDCTC-01). This also explains why Kayla, the women we commenced the paper with, had to stop showering in the middle of the night when the water stopped (SSICTC-01). Rokaya from Delft recounts she had to stop watering her vegetable garden which provided her with some food (FGDCTC-01). The same occurred to many of the people living in the Cape Flats who saw their vegetable gardens and livelihood slowly disappear (SSINGO-05). What is striking here is the contrast between the upper or middle classes and the townships in experiencing the drought. In fact, whilst the former could not meet their high standards of water consumption, townships' dwellers could not even satisfy their basic needs. Additionally, the townships experienced severe water shortages, which forced them to harsher conditions compared to the wealthier suburbs (SSINGO-01). In this situation people in the townships tried to use less water, prioritized water uses by taking fewer showers, and recycled water (FGDCTC-01). On days in which water was cut abruptly, women got up as early as 4am to make best use of the water available. Only a few families with strong networks and local ties, managed to get additional water from corrupt water operators (FGDCTC-02). The others had to survive water shortages on their own. In fact, from the City or the Government there was very little information targeting this social group who was left with little or no assistance (SSINGO-02).

Alongside the crisis management strategy of the government that favoured middle class and upper class residents, the harsher experience of the drought in townships was determined by residents' socio-economic status. Townships dwellers had limited resources to implement coping strategies such as rainwater tanks or boreholes at household level. For some, even bottled water was too expensive. Furthermore, also the composition of the household and the number of people living in each unit shaped their experience of drought. Finally, drilling a borehole or finding a fresh water spring is nearly impossible as these neighbourhoods are too densely populated. Without access to alternative supplies, townships residents had to solely rely on the water provided by the city and "*it was really bad!*" (SSICTC-01). In contrast with the resilience trajectories of the upper classes, we have observed that the inhabitants of these lower-class neighbourhoods have seemingly reduced their level of water security relative to before the drought. In a short amount of time, they lost their free-basic water service, they have had to cope with the increased tariff and, in some cases, the water metering devices reduced the maximum amount of water they could use on a daily basis.

Informal settlements were largely overlooked by the Day Zero campaign. For some authorities, their use of water was already so little that they should be "*resilient enough*" to face the crisis. They claimed that the drought barely affected residents of informal settlements because they always lived with very little water (SSIG-01, SSIG-02). Indeed, activist in the area confirmed that water shortage in these areas is chronic: there, "*every day is a Day Zero*" (SSIM-03). Yet, the approach taken by local authorities shows how historical inequalities are dangerously mobilised to justify a crisis management strategy that overlooked the most vulnerable and, in turn, exacerbated existing inequalities.

4.4. Resilience trajectories of Cape Town's urban areas

Our findings reveal that, whilst the general perception of city government and international media was that the middle and upper class were the most affected by the crisis, water insecurity experienced in the townships and informal areas was more intense in terms of both duration, severity and outcomes. Local authorities discursively framed Day Zero as a middle class' crisis (SSIG-01, SSIG-02), even though those suburbs rarely experienced real water shortages. After an initial shock due to water restrictions, many were able to implement coping strategies and ensure a greater amount of water for their household. In the end, what middle and upper class actually experienced was the imposed limitation from their ordinary unsustainable water consumption. By contrast, townships' dwellers could not afford alternative water sources and often remained without any water for their basic needs. Meanwhile the informal settlements chronic conditions of water insecurity persisted (SSIM-02).

Accordingly, the question that arises is to what extent can this uneven geography of water be attributed to the physical water scarcity of the latest drought? Our analysis of Cape Town Day Zero, suggests that the different experiences of drought reproduce the same power structures and inequalities that existed long before Day Zero. Overtime, the legacy of colonization, segregation, and neoliberalisation of Cape Town urban spaces, has engendered the way the latest drought manifested itself and was unevenly experienced across the city. These sociohydrological processes produced uneven geographies of water insecurities characterised by disadvantaged and water insecure black spaces and water secure white spaces where unsustainable water use is the norm.

These same dynamics are reflected in the resilience trajectories of different societal groups. Building upon our qualitative investigation, we developed Fig. 3 to further illustrate this point. The analysis of Capetonians water access and consumption revealed that different societal groups (city elite, upper middle class, lower middle class, townships and informal dwellers) already experienced unequal conditions of water

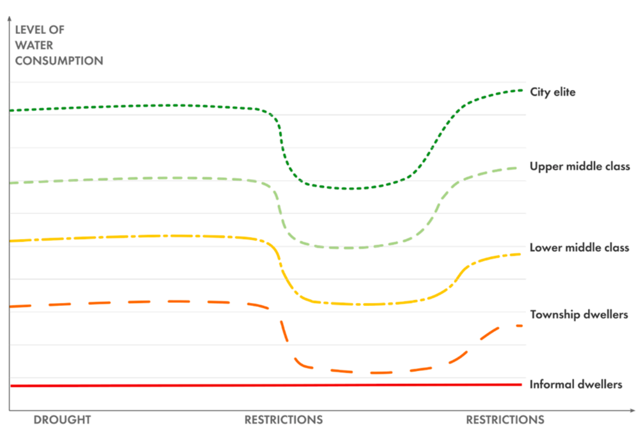

Fig. 3. Trajectories of water (in)security across Cape Town's diverse societal groups. The authors have elaborated this diagram on the basis of their qualitative analysis before and during the 2015–17 drought. Each trajectory aims at retracing the average level of water consumption over time for every societal group. Upper classes have recovered quicker than the others and improved their water security level. Instead, lower classes took a longer time to recover and eventually reduced their level of water insecurity relative to before the water crisis. Informal dwellers' trajectory remains stable because in those areas the level of water consumption is always below the minimum standard imposed by National water policies and as a result, they were not subjected to any water restrictions. For them, 'every day is a Day Zero'.

security before the onset of the drought.

Furthermore, we observed that the occurrence of the 2015–17 drought mostly accelerated a pre-existing water crisis and exacerbated the level of water (in)security of every Capetonian. Yet, according to our investigation, the wealthier households (upper class and upper middle class) managed to enhance water security by going off-the-grid and ensuring their access to alternative water sources. At the same time, the most disadvantaged communities ended up worsening or remaining in their initial conditions. Thus, we argue that the drought engendered different resilience trajectories that cannot be generalized nor merged as a common societal response as they express distinctive human-water systems interactions. Together, these resilience trajectories illustrate the politics at play in human-water systems and retrace diverse human interactions with hydrology.

5. Conclusions and future implications

We commenced this paper by asking what made the water insecurity levels of Kayla and the Du Plessis family so different, considering that they were experiencing the same drought. To answer this question, we have developed an interdisciplinary approach that places sociohydrological insights into engagement with political ecology perspectives.

Drawing on sociohydrology we shed light on the socio-technical and hydrological processes that, over time, shape the status of water resources and their often unsustainable uses. Through a political ecology lens, we teased out the political drivers and consequences of these sociohydrological phenomena. Our qualitative analysis before the drought onset, has revealed that the wealthier Cape Town suburbs had reached unsustainable levels of water consumption and in turn, engendered different impacts on the local water resources relative to the lower classes. In addition, the analysis of diverse experiences of drought shed light on unequal resilience trajectories across Cape Town social groups. We showed why these different trajectories matter and should not be homogenised or concealed into a common societal response.

As a first attempt to integrate sociohydrology with political ecology, this paper shows the potential of advancing understanding of water insecurity and hydrological extremes. However, the qualitative analysis performed does not allow to quantify the extent to which the *politics* we describe, has contributed to reshape Cape Town's water systems and, eventually, to transform the drought into the Day Zero crisis. The main reason for this limitation is the unavailability of reliable and complete data on water consumption across Cape Town neighbourhoods. Yet, we believe that our approach can inspire and inform a new generation of sociohydrologists in quantifying and/or capturing the ways in which different political forces can engender and reshape water (in)security. In the mid-term, new interdisciplinary case-studies can reveal other mechanisms underlying human-water systems interactions. Those case studies with access to reliable data and information should also aim at quantifying the diverse impacts that distinctive human feedbacks engender on water systems. In the long term, we believe that the insights gained from these examinations, would encourage the development of new system dynamics models accounting for social power and inequalities that reshape human-water systems.

Overall, our critical analysis served to define water insecurity as a complex phenomenon engendered by sociohydrological processes and the underlying political transformations in the struggle for control over wealth, land and water. By challenging depoliticised notions of water security, we aim at persuading sociohydrologists and policy makers to account for the political factors that produce and exacerbate uneven geographies of water insecurity. In turn, we argue that the relevance of this political understanding hinges on the fact that power imbalances are the driving mechanisms that determine what water is secured and what human-water interactions and dynamics will be sustained over time.

On these grounds, we posit that water insecurity cannot be addressed solely by augmenting physical availability of water. Technical solutions like water supply expansion projects or demand management strategies are not sufficient. In our view, the first step should be acknowledging and addressing the powerful interest that hamper a more sustainable and equitable distribution of the available water across society. Cape Town newspapers are, again, warning that the city has reached a water consumption level of 700 ML/day (similar to where it had been before the crisis) and this figure seems to increase on a weekly basis (Ngqakamba, 2019). Without a systemic change of the political and economic system and the consumption practices of *some* societal groups, Cape Town could experience another crisis in case of future droughts and the most marginalized groups—including the environment—will continue to bear the brunt.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

Adger, W.N., 2003. Social capital, collective action, and adaptation to climate change. Econ. Geogr. 79 (4), 387–404. https://doi.org/10.1111/j.1944-8287.2003.tb00220.x.

Ahlers, R., 2010. Fixing and nixing: the politics of water privatization. Rev. Radical Polit. Econ. 42 (2), 213–230. https://doi.org/10.1177/0486613410368497.

Alda-Vidal, C., Kooy, M., Rusca, M., 2018. Mapping operation and maintenance: an everyday urbanism analysis of inequalities within piped water supply in Lilongwe, Malawi. Urban Geogr. 39 (1), 104–121. https://doi.org/10.1080/02723638.2017.1292664.

Anand, N., 2011. Pressure: the politechnics of water supply in Mumbai. Cult. Anthropol. 26 (4), 542–564. https://doi.org/10.1111/j.1548-1360.2011.01111.x.

Baker, A., 2018. What It’s Like to Live through Cape Town’s Massive Water Crisis. TIME Magazine. TIME’s Africa. Available at: https://time.com/cape-town-south-africa-water-crisis/ (Accessed 16/11/2020).

Bakker, K., 2003. Archipelagos and networks: urbanization and water privatization in the South. Geogr. J. 169 (4), 328–341. https://www.jstor.org/stable/3451572.

Bakker, K., 2007. The “commons” versus the “commodity”: alter-globalization, anti-privatization and the human right to water in the global south. Antipode 39 (3), 430–455. https://doi.org/10.1111/j.1467-8330.2007.00534.x.

Bakker, K., 2012. Water security: research challenges and opportunities. Science 337 (6097), 914–915. https://doi.org/10.1126/science.1226337.

Bankoff, G., 2003. Constructing vulnerability: the historical, natural and social generation of flooding in metropolitan manila. Disasters 27 (3), 224–238. https://doi.org/10.1111/1467-7717.00230.

Botai, C., Botai, J., de Wit, J., Ncongwane, K., Adeola, A., 2017. Drought characteristics over the Western Cape Province, South Africa. Water Policy 9 (11), 876. https://doi.org/10.3390/w9110876.

Brenner, N., Theodore, N., 2002. Cities and the geographies of actually existing neoliberalism. Antipode 34 (3), 349–379. https://doi.org/10.1111/1467-8330.00246.

COCT, 2014. Cape Town 2011 Census Socio-Economic Index, City of Cape Town Development Information and GIS Department, 61 Pages. Available at: http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/16429%20COCT%20State%20of%20Cape%20Town%20Report%202016%20FINAL.pdf (Accessed 16/12/2019).

COCT, 2018. City of Cape Town Water Outlook Report 2018. Available at: http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/Water%20Outlook%202018%20-%20Summary.pdf (Accessed 16/12/2019).

COCT, 2020. City of Cape Town Open Data Portal. Available at: https://web1.capetown.gov.za/web1/OpenDataPortal/ (Accessed 11/11/2020).

Collins, T.W., 2010. Marginalization, facilitation, and the production of unequal risk: the 2006 Paso Del Norte floods. Antipode 42 (2), 258–288. https://doi.org/10.1111/j.1467-8330.2009.00755.x.

Conradie, W.S., 2018. Why Is Cape Town Running out of Water?. CSAG Climate System Analysis Group. Available at: http://www.csag.uct.ac.za/2018/02/21/cape-town-running-out-of-water/ (Accessed 16/11/2020).

Currie, P.K., Musango, J.K., May, N.D., 2017. Urban metabolism: a review with reference to Cape Town. Cities 70, 91–110. https://doi.org/10.1016/j.cities.2017.06.005.

Deklerk, A., 2018. De Lille Pushes the Drought Panic Button. Sunday Times. News South Africa. Available at: https://www.timeslive.co.za/news/south-africa/2018-01-18-de-lille-pushes-the-drought-panic-button/ (Accessed 16/11/2020).

Di Baldassarre, G., Nohrstedt, D., Mård, J., Burchardt, S., Albin, C., Bondesson, S., Breinl, K., Deegan, F.M., Fuentes, D., Lopez, M.G., 2018a. An integrative research framework to unravel the interplay of natural hazards and vulnerabilities. Earth’s Fut. 6 (3), 305–310. https://doi.org/10.1002/2017EF000764.

Di Baldassarre, G., Sivapalan, M., Rusca, M., Cudennec, C., Garcia, M., Kreibich, H., Konar, M., Mondino, E., Mård, J., Pande, S., 2019. Sociohydrology: scientific challenges in addressing the sustainable development goals. Water Resour. Res. 55 (8), 6327–6355. https://doi.org/10.1029/2018WR023901.

Di Baldassarre, G., Wanders, N., AghaKouchak, A., Kuil, L., Rangecroft, S., Veldkamp, T. I., Garcia, M., van Oel, P.R., Breinl, K., Van Loon, A.F., 2018b. Water shortages worsened by reservoir effects. Nat. Sustain. 1 (11), 617–622. https://doi.org/10.1038/s41893-018-0159-.

Douglass, M., Miller, M.A., 2018. Disaster justice in Asia’s urbanising anthropocene. Environ. Plann. E Nat. Space 1 (3), 271–287. https://doi-org.ezproxy.its.uu.se/10.1177/2514848618797333.

Ekers, M., Loftus, A., 2008. The power of water: developing dialogues between Foucault and Gramsci. Environ. Plann. D Soc. Space 26 (4), 698–718. https://doi.org/10.1068/d5907.

Ertsen, M., Murphy, J., Purdue, L., Zhu, T., 2014. A journey of a thousand miles begins with one small step-human agency, hydrological processes and time in socio-hydrology. Hydrol. Earth Syst. Sci. 18 (4), 1369–1382. https://doi.org/10.5194/hess-18-1369-2014.

Evers, M., Höllermann, B., Almoradie, A.D.S., Garcia Santos, G., Taft, L., 2017. The pluralistic water research concept: a new human-water system research approach. Water 9 (12), 933. https://doi.org/10.3390/w9120933.

Fothergill, A., Maestas, E.G., Darlington, J.D., 1999. Race, ethnicity and disasters in the United States: a review of the literature. Disasters 23 (2), 156–173. https://doi.org/10.1111/1467-7717.00111.

Garcia, M., Portney, K., Islam, S., 2016. A question driven socio-hydrological modeling process. Hydrol. Earth Syst. Sci. 20 (1) https://doi.org/10.5194/hessd-12-8289-2015.

Garcia, M., Koebele, E., Deslatte, A., Ernst, K., Manago, K.F., Treuer, G., 2019. Towards urban water sustainability: analyzing management transitions in Miami, Las Vegas, and Los Angeles. Global Environ. Change 58, 101967. https://doi.org/10.1016/j.gloenvcha.2019.101967.

Garcia, M., Ridolfi, E., Di Baldassarre, G., 2020. The interplay between reservoir storage and operating rules under evolving conditions. J. Hydrol. 590, 125270 https://doi.org/10.1016/j.jhydrol.2020.125270.

Gohari, A., Eslamian, S., Mirchi, A., Abedi-Koupaei, J., Bavani, A.M., Madani, K., 2013. Water transfer as a solution to water shortage: a fix that can backfire. J. Hydrol. 491, 23–39. https://doi.org/10.1016/j.jhydrol.2013.03.021.

Grey, D., Sadoff, C.W., 2007. Sink or swim? Water security for growth and development. Water Policy 9 (6), 545–571. https://doi.org/10.2166/wp.2007.021.

Guerreiro, S.B., Dawson, R.J., Kilsby, C., Lewis, E., Ford, A., 2018. Future heat-waves, droughts and floods in 571 European cities. Environ. Res. Lett. 13 (3), 034009.

Hameeteman, E., 2013. Future Water (in) Security: Facts, Figures, and Predictions. Global Water Institute, pp. 1–16.

Harvey, D., 2006. Neo-liberalism as creative destruction. Geografiska Ann. Series B Human Geogr. 88 (2), 145–158. https://doi.org/10.1111/j.0435-3684.2006.00211.x.

Ikeme, J., 2003. Equity, environmental justice and sustainability: incomplete approaches in climate change politics. Global Environ. Change 13 (3), 195–206. https://doi.org/10.1016/S0959-3780(03)00047-5.

Jaglin, S., 2008. Differentiating networked services in Cape Town: echoes of splintering urbanism? Geoforum 39 (6), 1897–1906. https://doi.org/10.1016/j.geoforum.2008.04.010.

Kallis, G., 2010. Coevolution in water resource development: the vicious cycle of water supply and demand in Athens, Greece. Ecol. Econ. 69 (4), 796–809. https://doi.org/10.1016/j.ecolecon.2008.07.025.

Kooy, M., Bakker, K., 2008. Splintered networks: the colonial and contemporary waters of Jakarta. Geoforum 39 (6), 1843–1858. https://doi.org/10.1016/j.geoforum.2008.07.012.

Koopman, M., de Buys, A., 2017. What Do Long-Term Data Reveal about Cape Town’s Water Shortage? South African Environmental Observation Network. eNewsletter, National Research Foundation. Available at: http://www.saeon.ac.za/enewsletter/archives/2017/october2017/doc01 (Accessed 15/12/2019).

Leff, E., 2015. The power-full distribution of knowledge in political ecology: a view from the South. Routledge Handbook Polit. Ecol. 64–75.

Lemanski, C., 2007. Global cities in the south: deepening social and spatial polarisation in Cape Town. Cities 24 (6), 448–461. https://doi.org/10.1016/j.cities.2007.01.011.

Leng, G., Tang, Q., Rayburg, S., 2015. Climate change impacts on meteorological, agricultural and hydrological droughts in China. Global Planet. Change 126, 23–34. https://doi.org/10.1016/j.gloplacha.2015.01.003.

Loftus, A., 2012. Everyday Environmentalism: Creating an Urban Political Ecology. University of Minnesota Press.

Loftus, A., 2015. Water (in) security: securing the right to water. Geogr. J. 181 (4), 350–356. https://doi.org/10.1111/geoj.12079.
Loftus, A.J., McDonald, D.A., 2001. Of liquid dreams: a political ecology of water privatization in Buenos Aires. Environ. Urbaniz. 13 (2), 179–199. https://doi.org/10.1177/095624780101300215.
Loftus, A., March, H., Purcell, T.F., 2019. The political economy of water infrastructure: an introduction to financialization. Wiley Interdisc. Rev. Water 6 (1), e1326. https://doi.org/10.1002/wat2.1326.
Longhurst, R., 2003. Semi-structured interviews and focus groups. Key Methods Geogr. 3 (2), 143–156.
Lutz-Ley, A.N., Scott, C.A., Wilder, M., Varady, R.G., Ocampo-Melgar, A., Lara-Valencia, F., Zuniga-Teran, A., Buechler, S., Díaz-Caravantes, R., Ribeiro-Neto, A., Pineda-Pablos, N., 2020. Dialogic science-policy networks for water security Governance in the arid Americas. Environ. Dev. 100568. https://doi.org/10.1016/j.envdev.2020.100568.
Mawani, V., 2019. Unmapped water access: locating the role of religion in access to municipal water supply in Ahmedabad. Water 11 (6), 1282. https://doi.org/10.3390/w11061282.
McDonald, D.A., 2012. World City Syndrome: Neoliberalism and Inequality in Cape Town. Routledge.
McDonald, D.A., Smith, L., 2004. Privatising Cape Town: from apartheid to neo-liberalism in the mother city. Urban Stud. 41 (8), 1461–1484. https://doi.org/10.1080/0042098042000226957.
McFarlane, C., 2018. Fragment urbanism: politics at the margins of the city. Environ. Plann. D Soc. Space 36 (6), 1007–1025. https://doi.org/10.1177/0263775818777496.
McGaffin R., 2018. Housing in Cape Town in 2018 – A Draft Discussion Document Urban Real Estate Research Unit – University of Cape Town. Available at: http://www.ureru.uct.ac.za/sites/default/files/image_tool/images/383/Housing%20in%20Cape%20Town-2018.pdf (Accessed 15/09/2020).
Millington, N., Scheba, S., 2020. Day zero and the infrastructures of climate change: water governance, inequality, and infrastructural politics in Cape Town's water crisis. Int. J. Urban Reg. Res. https://doi.org/10.1111/1468-2427.12899.
Miraftab, F., 2007. Governing post apartheid spatiality: implementing city improvement districts in Cape Town. Antipode 39 (4), 602–626. https://doi.org/10.1111/j.1467-8330.2007.00543.x.
Miraftab, F., 2012. Colonial present: legacies of the past in contemporary urban practices in Cape Town, South Africa. J. Plann. History 11 (4), 283–307. https://doi.org/10.1177/1538513212447924.
Mishra, A.K., Singh, V.P., 2010. A review of drought concepts. J. Hydrol. 391 (1–2), 202–216. https://doi.org/10.1016/j.jhydrol.2010.07.012.
Montanari, A., 2015. Debates – perspectives on socio-hydrology: introduction. Water Resour. Res. 51 (6), 4768–4769. https://doi.org/10.1002/2015WR017430.
Mustafa, D., 2005. The production of an urban hazardscape in Pakistan: modernity, vulnerability, and the range of choice. Ann. Assoc. Am. Geogr. 95 (3), 566–586. https://doi.org/10.1111/j.1467-8306.2005.00475.x.
Nature, 2019. End the Drought in Drought Research. Nature Editorial. 573, 310. Available at https://www.nature.com/articles/d41586-019-02782-3 (Accessed 16/11/2020).
Ngqakamba, S., 2019. Cape Town Water Consumption Increases by 28 Million Litres Per Day. News24. Available at: https://www.news24.com/news24/southafrica/news/cape-town-water-consumption-increases-by-28-million-litres-per-day-20190715 (Accessed 16/11/2020).
Otto, F.E., Wolski, P., Lehner, F., Tebaldi, C., Van Oldenborgh, G.J., Hogesteeger, S., Singh, R., Holden, P., Fučkar, N.S., Odoulami, R.C., New, M., 2018. Anthropogenic influence on the drivers of the Western Cape drought 2015–2017. Environ. Res. Lett. 13 (12) https://doi.org/10.1088/1748-9326/aae9f9.
Pelling, M., 1999. The political ecology of Flood Hazard in Urban Guyana. Geoforum 30 (3), 249–261. https://doi.org/10.1016/S0016-7185(99)00015-9.
Perreault, T., Bridge, G., McCarthy, J., 2015. The Routledge Handbook of Political Ecology. Routledge.
Peters, K., Oldfield, S., 2005. The paradox of 'free basic water' and cost recovery in Grabouw: increasing household debt and municipal financial loss. Urban Forum. 16 (4), 313–335. https://doi.org/10.1007/s12132-005-0009-9.
Pihljak, L.H., Rusca, M., Alda-Vidal, C., Schwartz, K., 2019. Everyday practices in the production of uneven water pricing regimes in Lilongwe, Malawi. Environ. Plann. C Polit. Space. https://doi.org/10.1177/2399654419856021.
Robins, S., 2019. 'Day Zero', hydraulic citizenship and the defence of the commons in cape town: a case study of the politics of water and its infrastructures (2017–2018). J. Southern Afr. Stud. 45 (1), 5–29. https://doi.org/10.1080/03057070.2019.1552424.
Rusca, M., dos Santos, T., Menga, F., Mirumachi, N., Schwartz, K., Hordijk, M., 2018. Space, state-building and the hydraulic mission: crafting the Mozambican state. Environ. Plann. C Polit. Space 37 (5), 868–888. https://doi.org/10.1177/0263774X18812171.
Russell, M., 1998. Black urban households in South Africa. Afr. Sociol. Rev./Revue Afr. Sociol. 174–180. https://www.jstor.org/stable/44895994.
Sanderson, M.R., 2018. Everything Flows… unevenly: social stratification in coupled socio-ecological systems. Curr. Opinion Environ. Sustain. 33, 51–57. https://doi.org/10.1016/j.cosust.2018.04.012.
Schiermeier, Q., 2018. Droughts, heatwaves and floods: How to tell when climate change is to blame. Nature 560, 20–22. Available at: https://www.nature.com/articles/d41586-018-05849-9 (Accessed 16/11/2020).
Schifman, L.A., Herrmann, D.L., Shuster, W.D., Ossola, A., Garmestani, A., Hopton, M.E., 2017. Situating green infrastructure in context: a framework for adaptive socio-hydrology in cities. Water Resour. Res. 53 (12), 10139–10154.
Secor, A., 2010. Social surveys, interviews, and focus groups. In: Gomez, B., Jones, J. (Eds.), Research Methods in Geography, 3, pp. 194–205.
Sivapalan, M., Konar, M., Srinivasan, V., Chhatre, A., Wutich, A., Scott, C.A., Wescoat, J. L., Rodríguez-Iturbe, I., 2014. Socio-hydrology: use-inspired water sustainability science for the Anthropocene. Earth's Fut. 2 (4), 225–230. https://doi.org/10.1002/2013EF000164.
Smith, L., 2001. The Urban Political Ecology of Water in Cape Town. Urban Forum, vol. 12, Springer-Verlag, No. 2, p. 204. http://link.springer.com/content/pdf/10.1007/s12132-001-0016-4.pdf.
Smith, L., Hanson, S., 2003. Access to water for the urban poor in Cape Town: where equity meets cost recovery. Urban Stud. 40 (8), 1517–1548. https://doi.org/10.1080/0042098032000094414.
Srinivasan, V., 2015. "Reimagining the past–use of counterfactual trajectories in socio-hydrological modelling: the case of Chennai, India. Hydrol. Earth Syst. Sci. 19 (2), 785–801. ISSN 1027-5606.
Srinivasan, V., Konar, M., Sivapalan, M., 2017. A dynamic framework for water security. Water Security 1, 12–20. https://doi.org/10.1016/j.wasec.2017.03.001.
Storm, S., 2009. Capitalism and climate change: can the invisible hand adjust the natural thermostat? Dev. Change 40 (6), 1011–1038. https://doi.org/10.1111/j.1467-7660.2009.01610.x.
Swyngedouw, E., 1997. Power, nature, and the city. The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador: 1880–1990. Environ. Plann. A 29 (2), 311–332. https://doi.org/10.1068/a290311.
Swyngedouw, E., 1999. Modernity and hybridity: nature, Regeneracionismo, and the production of the Spanish waterscape, 1890–1930. Ann. Assoc. Am. Geogr. 89 (3), 443–465. https://doi.org/10.1111/0004-5608.00157.
Swyngedouw, E., 2005. Dispossessing H2O: the contested terrain of water privatization. Capital. Nat. Social. 16 (1), 81–98. https://doi.org/10.1080/1045575052000335384.
Sultana, F., 2009. Fluid lives: subjectivities, gender and water in rural Bangladesh. Gender Place Cult. 16 (4), 427–444. https://doi.org/10.1080/09663690903003942.
Sultana, F., 2011. Suffering for water, suffering from water: emotional geographies of resource access, control and conflict. Geoforum 42, 163–172. https://doi.org/10.1016/j.geoforum.2010.12.002.
Sultana, F., 2018. Water justice: why it matters and how to achieve it. Water Int. 43, 483–493. https://doi.org/10.1080/02508060.2018.1458272.
Tiwale, S., Rusca, M., Zwarteveen, M., 2018. The power of pipes: mapping urban water inequities through the material properties of networked water infrastructures-the case of Lilongwe, Malawi. Water Altern. 11(2), 314–335. http://www.water-alternatives.org/index.php/alldoc/articles/vol11/v11issue2/439-a11-2-6.
Trenberth, K.E., Dai, A., Van Der Schrier, G., Jones, P.D., Barichivich, J., Briffa, K.R., Sheffield, J., 2014. Global warming and changes in drought. Nat. Clim. Change 4 (1), 17–22. https://doi.org/10.1038/nclimate2067.
Troy, T.J., Pavao-Zuckerman, M., Evans, T.P., 2015. Debates—perspectives on socio-hydrology: socio-hydrologic modeling: tradeoffs, hypothesis testing, and validation. Water Resour. Res. 51 (6), 4806–4814. https://doi.org/10.1002/2015WR017046.
Truelove, Y., 2011. (Re-) Conceptualizing water inequality in Delhi, India through a feminist political ecology framework. Geoforum 42 (2), 143–152. https://doi.org/10.1016/j.geoforum.2011.01.004.
Truelove, Y., 2016. Incongruent waterworlds: situating the everyday practices and power of water in Delhi. South Asia Multidisc. Acad. J. (14). https://doi.org/10.4000/samaj.4164.
UNESCO and UNESCO i-WSSM, 2019. Water Security and the Sustainable Development Goals (Series l). Global Water Security Issues (GWSI) Series, UNESCO Publishing, Paris.
UN-Water, 2013. Water security and the global water agenda. A UN-Water analytical brief. Hamilton: United Nations University. ISBN: 9789280860382.
Van Lanen, H., Wanders, N., Tallaksen, L., Van Loon, A., 2013. Hydrological drought across the world: impact of climate and physical catchment structure. Hydrol. Earth Syst. Sci. 17, 1715–1732. https://doi.org/10.5194/hess-17-1715-2013.
Verchick, R., 2012. Disaster justice: the geography of human capability. Duke Environ. Law Policy Forum 23 (1).
Viglione, A., Di Baldassarre, G., Brandimarte, L., Kuil, L., Carr, G., Salinas, J.L., Scolobig, A., Blöschl, G., 2014. Insights from socio-hydrology modelling on dealing with flood risk-roles of collective memory, risk-taking attitude and trust. J. Hydrol. 518, 71–82. https://doi.org/10.1016/j.jhydrol.2014.01.018.
Viljoen, N., 2016. City of Cape Town Residential Water Consumption Trend Analysis. City of Cape Town. Available at: https://greencape.co.za/assets/Sector-files/water/Water-conservation-and-demand-management-WCDM/Viljoen-City-of-Cape-Town-residential-water-consumption-trend-analysis-2014-15-2016.pdf (Accessed 16/11/2020).
Walton, B., 2018. How Cape Town Got to the Brink of Water Catastrophe. CityLab. Environment. Available at: bloomberg.com/citylab/M6Lbrcf (Accessed 15/12/2019).
Wesselink, A., Kooy, M., Warner, J., 2017. Socio-hydrology and hydrosocial analysis: toward dialogues across disciplines. Wiley Interdisc. Rev. Water 4 (2), e1196. https://doi.org/10.1002/wat2.1196.
Wheater, H.S., Gober, P., 2015. Water security and the science agenda. Water Resour. Res. 51 (7), 5406–5424. https://doi.org/10.1002/2015WR016892.
Williamson, F., 2018. The politics of disaster: the great Singapore flood of 1954. Environ. Plann. E Nat. Space 1 (3), 323–339. https://doi.org/10.1177/2514848618776872.
Wilson, N.J., Harris, L.M., Nelson, J., Shah, S.H., 2019. Re-theorizing politics in water governance. Water 11, 1470. https://doi.org/10.3390/w11071470.
Winter, K., 2018. Five Signs That Day Zero May Be Averted. The University of Cape Town News. Available at: https://www.news.uct.ac.za/article/-2018-01-23-five-signs-that-day-zero-may-be-averted (Accessed 16/11/2020).

Wisner, B., Blaikie, P.M., Blaikie, P., Cannon, T., Davis, I., 2004. At risk: Natural Hazards, People's Vulnerability and Disasters. Psychology Press.
Wolski, P., 2018. How severe is Cape Town's "day zero" drought? Significance 15, 24–27. https://doi.org/10.1111/j.1740-9713.2018.01127.x.
WWF, 2020. Cape Town's groundwater under the spotlight. Online Webinar. Available at: https://africa.panda.org/food_footer/?uNewsID=32522 (Accessed 19/11/2020).
Zeitoun, M., Lankford, B., Krueger, T., Forsyth, T., Carter, R., Hoekstra, A.Y., Taylor, R., Varis, O., Cleaver, F., Boelens, R., Swatuk, L., 2016. Reductionist and integrative research approaches to complex water security policy challenges. Global Environ. Change 39, 143–154. https://doi.org/10.1016/j.gloenvcha.2016.04.010.
Zwarteveen, M., Boelens, R., 2014. Defining, Researching and Struggling for water justice: some conceptual building blocks for research and action. Water Int. 39 (2), 143–158. https://doi.org/10.1080/02508060.2014.891168.
Zwarteveen, M., Kemerink-Seyoum, J.S., Kooy, M., Evers, J., Guerrero, T.A., Batubara, B., Biza, A., Boakye-Ansah, A., Faber, S., Cabrera Flamini, A., 2017. Engaging with the politics of water governance. Wiley Interdisc. Rev. Water 4 (6), e1245. https://doi.org/10.1002/wat2.1245.