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Climate gating: A case study of emerging responses to Anthropocene Risks

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ABSTRACT

This article explores responses to one type of climate risk, severe water scarcity, during Cape Town's drought from 2016 to mid-2018. Advancing our understanding of how societies can cope and develop despite disruptions, it considers how selected pathways shaped noteworthy response diversity to mitigate the impact and potential harms associated with the unprecedented drought. Enhancing capacity through off-grid alternatives, private responses led to the emergence of innovative arrangements, at extraordinary scales, to adaptively secure variants of household level water access and reserves while expanding general reserve margins. Unintended consequences of nascent off-grid capacity arrangements precipitated transformations and accommodation challenges to public governance systems. We relate these observations to emerging trends in 'off-grid' provision of goods by non-state actors, seen in other fields, a phenomenon we call 'climate gating'. These observations highlight what is and what is not potentially safeguarded by such decentralised and polycentric responses.

1. Introduction

We live in an 'age of uncertainty' across multiple spheres (O'Malley, 2003). One such sphere is the arena of shifting earth systems, that the term 'Anthropocene' (Crutzen and Stoermer, 2000) recognises (for examples of critical discussion of this term see, Harrington and Shearing, 2017; Subramanian, 2019). Considerable research has taken place across a variety of domains – for example, insurance and the financial industries (Clarvis et al., 2015), energy transition and transitions generally (Geels and Raven, 2006; Grey and Sadoff, 2007), that explore variations in responses to shifts in earth systems. The threat of such changes to a sustainable future has led scholars to pay increasing attention to novel kinds of risks, hazards and harms. Woodward (2019) has recently cautioned that the most threatening of such disruptions are those of low predictability, high scale, speed and irreversibility. With varying degrees of expression, the Cape Town drought exhibited all these characteristics as public and private actors grappled with reliability of rainfall forecasts and water supply models, acted at unprecedented scales and speeds in endeavours to explore and bring online alternative supply sources, all of which amounted to establish novel governance arrangements around water and future corrigibility.

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These shifts in risk governance are rewriting established 'harmscapes' (Berg and Shearing, 2018), and approaches to security. By 'harmscapes' we reference the broad range of unsecured harms posed by heightened risks and hazards associated with an altered earth. This is similar to existing notions of 'riskscapes' (Morello-Frosch et al., 2001) or 'hazardscapes' (Mustafa, 2005), but includes a broader view of exposure to unprecedented harms associated with major social, economic, environmental or technological disruption. For example, concerning anticipated health harms scholars have associated with Anthropocene changes, Whitmee et al. (2015, p. 1974) highlight, "environmental threats to human health and human civilisation will be characterised by surprise and uncertainty", as society we "face clear and potent dangers that require urgent and transformative actions to protect present and future generations". The uncertainties associated with these harmscapes have presented significant challenges, to both professionals and laypersons, seeking to manage or provide safeguards for these developments, such as climate variability, so as to promote environmental securities. By security actors we reference those who manage or respond to security issues, broadly conceptualised (Dupont, 2017; Ostrom, 2010), rather than simply those professionals with a security label (Pretorius, 2018). Any actors who undertake and select particular pathways to secure their interests against such harms are therefore included in the scope of 'security' actors. This opens up consideration of decentralised, private and polycentric nodes and actions in the name of governance (Ostrom, 2010), security (Berg and Shearing, 2008), and climate risk governance in particular (Vob and Schroth, 2019).

Existing approaches to water security generally converge on defining it in terms of abundance or scarcity (Jepson et al., 2017), with frameworks aiming to understand physical resource availability, infrastructure and economic choices (Srinivasan et al., 2017), and shaped by interacting domains of concern such as, social, demographic, economic, technological, ecological, and governance (Romero-Lankao and Gnatz, 2016). Although water security and resilience literatures are dominated by a focus on public and/or utility scale provision of water for general distribution (Yazdani et al., 2011; Ziervogel et al., 2010), in departure from a centralised focus, it is this issue of securing private and household level supply, that we explore via an analysis of Cape Town's response to a recent drought that seriously undermined the City's water security. In further departure from uses of resilience as a means of understanding and framing both public and private responses to disruption and scarcity, common to framings and analyses of the drought (for some examples, De Lille, 2017a; Luker and Harris, 2018; Rodina, 2019; Simpson et al., 2019b), this study concentrates on what is being done to secure household level water supply.

We explore how private actions responded to disruption within the constraints of shock, in particular we consider the role 'backburner' technologies (Braithwaite and Drahos, 2000) played, and are playing, in establishing off-grid nodes of security. These actions have underscored choices by private entities to moderate their dependence on the public system and its infrastructure (Simpson, 2019). For many residents, this has amounted to a partial, selective or wholesale detachment from the public 'water grid', in pursuit of water security (Simpson et al., 2019b). This development, observable in both business and households across the city, might be thought of as 'climate gating', a term that locates this trend within the context of a wider phenomena of decentralised service delivery involving private auspices and providers (Bayley and Shearing, 2001) such as 'gated communities' – an established phenomenon within South Africa and elsewhere (Bislev, 2004; Blakely and Snyder, 1997; Shearing and Stenning, 1983). This development is not dissimilar to a host of other private and decentralised actions in, for example, electricity (Jaglin, 2013; Van der Heijden, 2013), education (Hursh, 2005; Zajda, 2006), and health (Chapman, 2014; Poirier et al., 2014) moves, where the state's ability to deliver key 'public goods' have been, and are being, supplemented and/or replaced (Dubé et al., 2014). As our case study demonstrates these decentralisation, selective gating and off-gridding moves, particularly when linked, can have major implications for disrupted centrally designed urban institutions, such as public water utilities.

We begin with a literature review of security in the Anthropocene under conditions of disruption and scarcity and we frame household level responses to the drought from an emerging security perspective (Shearing, 2015). We then outline our methodology. This is followed by a brief overview of the Cape Town drought, a presentation of findings and our analysis of them. We conclude by explicating what we have learned about the ways in which individuals are responding to an unanticipated and disruptive event. Here we pay particular attention to the implications of our findings for understandings of what effect these actions have highlighting the emerging trend of 'climate gating'.

2. New (in)securities

Bakker and Morinville (2013) have identified water governance as critical to water security, and to the long-term sustainability of life on Earth. It is expected that evolving earth system changes will affect the frequencies and magnitudes of natural hazards, such as hurricanes (Kossin, 2018), droughts, blizzards, floods and fires (Wise et al., 2014). Traditional knowledge and governance paradigms, such as the assumption of stationarity (Milly et al., 2008), are likely to have little effect in dealing with these new harms (Ogden et al., 2013), highlighting the need for a greater understanding of the threats Anthropocene harmscapes pose to societies and how people respond to them. Water scarcity is conceptualised here as one such harmscape; an 'insecurity that has to be overcome' (Falkenmark, 2013, p. 1). Despite a proliferation of anticipatory toolkits for what to do (for some examples, The Rockefeller Foundation and ARUP, 2016; World Bank, 2018), and hypotheses of what might happen (Bai et al., 2016; Biermann et al., 2016; Dryzek, 2016; Steffen et al., 2018), there is a dearth of examples detailing the ways individuals perceive and respond to unprecedented disruptions attributed to such events and what the consequences of such actions mean for those seeking to shape the flow of events. This article includes within its domain of 'security', 'the very wide variety of activities and practices that are being carried out under the sign of 'security' (Valverde, 2014, p. 383). The case study described below, considers how a range of private actors responded to the disruption of their water scarcity through creating local reserve capacity in the form of boreholes, well points and water tanks.

3. Data collection and methodology

The research focussed on six main data sources, three providing quantitative data indicating consumption, water use and private responses to the drought and three providing contextualization of the drought governance arrangements. In recognition of the proliferation of rainwater harvesting technologies, unit sales data from South Africa's largest rain water harvesting and storage tank manufacturer and retailer were analysed. Although the five principal tank retailers and manufacturers were contacted, only one company shared their sales and market share data with us. The second data source relied on the City of Cape Town's reported changes in number of households they defined as 'high consumption' households (CoCT, 2017). A third data source was changes in the number of boreholes registered with the City (Jordan, 2019). A fourth data source was media reports – a source that provided data on response technologies, household strategies and shifting relationships between residents and the local municipality. Fifth, a review of the City of Cape Town's drought policies and media releases January 2009 and June 2019, provided information on how the City governs water supply and water distribution – with particular emphasis on changes in tariffs, fines, consumption data and registration of boreholes and well points. Sixth, publications exploring governance arrangements of the drought (for some examples, Booysen et al., 2019; Enqvist and Ziervogel, 2019; Simpson et al., 2019a, 2019b; Ziervogel, 2019) were reviewed.

4. Results

4.1. The Cape Town drought

Between 2015 and 2018, the water catchment area, known as the Western Cape Water Supply System (WCWSS), suffered its driest three-year period since the 1930s (CoCT, 2018a). Historical consumption patterns indicated that Cape Town, a city of four million people, would run out of water in early 2018 (CoCT, 2018a). Although there is a lack of definitive evidence linking this drought with human induced climate variability, the unprecedented nature and effect of the drought on the citizens and government of Cape Town (Simpson et al., 2019a), provides a useful case for considering the kinds of responses cities and their denizens may adopt, if the anticipated effects of climate system changes are manifested in coming years (Allan et al., 2013).

We explore what private measures contributed to the remarkable reduction in Cape Town's consumption, from 1200 ML/day (mega litres of water per day) in 2015, to 526 ML/day in mid-February 2018 – a global record (Ziervogel, 2019) – measures that were prompted by predictions offered by the City of a rapidly approaching a point when Cape Town would run out of water (Visser, 2018). This proved to be an alarming prospect to Capetonians who had long assumed that their municipality would provide for their water security (Booysen et al., 2019) – with this, a previously unthinkable possibility suddenly became thinkable.

As with so much else in South Africa, water usage in Cape Town was heavily skewed in favour of wealthier denizens with those living in informal housing, conservatively estimated to be 20,5% of the population, using very little water in comparison with their wealthier neighbours (Enqvist and Ziervogel, 2019). Further, about 10% of residents in Khayelitsha, one such informal settlement, have neither access to running water nor any form of toilet (see Enqvist and Ziervogel, 2019 for detailed analysis of water inequalities in Cape Town; and see Stats-SA, 2017 for information on well-known inequalities in South Africa). This meant that opportunities to reduce water consumption from the municipal water grid rested with higher level consumers – consumers who, because of their previous high levels of consumption, found the quota of 50 L per person per day that the City had imposed particularly onerous. This concern also extended to the prospect of having to line-up for water at water distribution points, for 25 L of water per person per day that the City was planning to implement should 'Day Zero' arrive where most the city's residential suburbs (excluding informal settlements) would be shut off (Ziervogel, 2019). A consequence of these concerns across a wide swath of Capetonians was that they looked for alternative, off grid, ways of meeting their water consumption requirements (CoCT, 2018a).

4.2. Rainwater harvesting tanks and groundwater access

Rain water harvesting and storage tanks (water tanks), private boreholes and grey water systems emerged as some of the most prolific strategies for enhancing household level water supply, for those who could afford them. A commonly purchased 2500 L tank costs roughly ZAR3000.00 (USD215.00), which is approximately half the total monthly income of the lowest income quintile of South Africans (Stats-SA, 2017). A shallow well point (> 9 m deep) and pump cost approximately ZAR10,000.00 (USD720.00), where as a major borehole reaching down 80 m to more permanent water cost approximately ZAR140,000.00 (USD10,000.00). In addition to the above technologies several larger companies commissioned private desalination plants which treat abstracted sea or groundwater for their private use (McClelland, 2019; Pace, 2019). Fig. 1 graphically represents the uptake of vertical water tanks with capacity between 1000 L and 20 000 L in Cape Town (National Sales & Marketing – "X Tanks", 2018)[4].

Sales of water tanks did not change significantly during the first year of the drought, with sales of tanks remaining within their previous ten-year average sales of 165 tanks per month (July 2013 – August 2015). In the first half of 2016, the drought was generally considered to be a challenging but temporary anomaly in rainfall patterns (Wolski, 2017). This inaction reflects confidence in the conventional supply system and the prevalence of a mentality that anticipated a return to 'normal' rainfall and no need for supplemental actions. Towards the end of 2016 there was an increase in sales, with 535 tanks sold in September (324% increase in sales compared with the monthly average), as early adopters began exploring alternative household level water security options.

[4] 'X Tanks' is an anonymizing pseudonym.

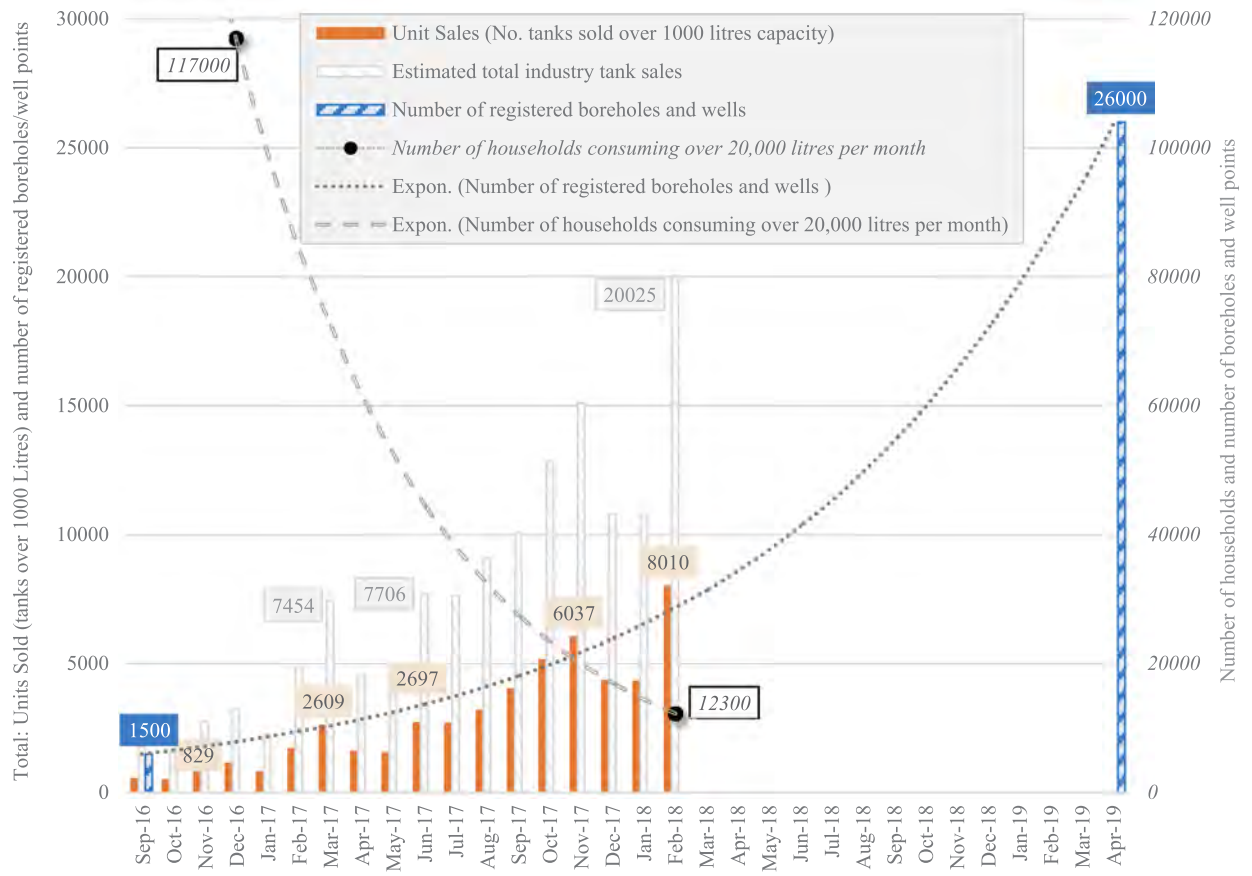

Fig. 1. Rainwater harvesting tank sales data, number of registered boreholes and well points, and reduction in number of households consuming more than 20,000L per month, Cape Town, Sept 2016-April 2019 (CoCT, 2018b; Jordan, 2019; National Sales & Marketing – "X Tanks", 2018).

Fig. 1 illustrates how a third consecutive year of water scarcity triggered a cascading increase in tank sales, a substantive shift towards water tanks as sales rose to an initial peak of 2609 tanks sold in March 2017. This spike marks the 21st month of the drought. General awareness (public and private) of the severity of the drought as a multi-year phenomenon and the government's inability to secure supply increased at this stage (De Lille, 2017b). There was a dip in sales through the first few (traditional) winter rainfall months of 2017 indicating the initial rainfall events had an impact on consumer behaviour. However, growing awareness of the worst rainfall season on record (Wolski et al., 2017), correlated with a dramatic increase in tank units sales during the second half of 2017. The rapid increase in sales from July 2017 onwards, tracks the adoption of rain water harvesting tanks as a private and household, an off-grid water securing strategy – 49,805 tanks were sold by 'X Tanks' between December 2016 and February 2018. 'X Tanks' market intelligence reports suggest that in February, when they sold 8010 units, they estimate over 20,000 tanks were sold in the Cape Town (interview, National Sales & Marketing – "X Tanks", 2018). These trends indicate an unprecedented demand for tanks which, over that period, was limited by availability (Palm, 2018).

In December 2016, 117,000 households were identified by the CoCT as using more than 20,000 L of municipal water per month (CoCT, 2017). Punitive demand management reached its height in the February 2018 which included a household allocation of 6000 L of water per month and substantial fines for those exceeding this amount.[5] By February 2018, through various demand management means, the number of 20,000 L plus households had been reduced to 12,300 (CoCT, 2018b). Over this 14-month period, 105,000 'high consumption' households curtailed their municipal water use (CoCT, 2018b), many of these households are likely to have installed water tanks to mitigate their consumption (see, Brick et al., 2018). Although 100,000 households are a small proportion of a total city of four million residents, their impact on total consumption was significant. Their off-gridding actions amounted to a 'shock within a shock' that threatened to undermine the City's revenue and tariff models, capital available for augmentation plans, and, significantly, the City's ability to cross-subsidize the approximately one million residents who do not pay for water (Simpson et al., 2019b).

Fig. 1 also indicates that in 2016 there were 1500 registered boreholes and wells in Cape Town, by April 2019, over 26,000 had been registered (Jordan, 2019). This indicates an unprecedented adoption of groundwater as a source of private water supply. These

[5] R1,536 (US$130) for consumption of 20,000 L, up to R20,000 (US$1,745) fine for 50,000 L per month.

developments prompted the CoCT to require all residents to register their boreholes (Jordan, 2019), ostensibly to provide the local government with information about the scale of this shift and its potential impact on groundwater. The conditions which drove selection and retention of rainwater harvesting tanks, indicate a likelihood that those utilising off-grid solutions are likely to continue to use these alternatives as a source of water. This has significant potential implications for the tax base of the CoCT, affecting operating and capital expenditure budgets and particularly the cross-subsidization of water revenues for poorer areas (Simpson et al., 2019b).

4.3. Climate gating and a new governance assemblage

The inability of the local government to maintain sufficient water flows during the Cape Town drought presented an unprecedented disruption to water access and management. An emerging response to disruptions of flows of water (and electricity) globally has given rise to a variety of 'off-grid' supply arrangements as an alternative to state provision (Simpson, 2019). In Cape Town for example, where both water and electricity disruptions have occurred, a response by many citizens and organisations has been to access alternative sources of supply and to move off public grids – either partially, or completely – to ensure continuity of their supply (Madonsela et al., 2019). These responses, Puerto Rico provides but one of many extended examples, are producing concerning resource inequalities and recovery challenges (Simpson, 2019).

In response to the Cape Town drought these private actions supplemented an anticipated lack in the public provision of water and introduced novel, decentralised water supply alternatives that reshaped the established water system. The case highlights the role that back-burner technologies can play in disrupting public systems of supply. Together, access to groundwater and water tanks that harvested water from hardened surfaces within CoCT, provide a dispersed reserve capacity. The effect of these actions on water governance and infrastructures went beyond resourcefulness of consumers to include transformative characteristics, creating pathways that did not exist previously – pathways that were replicated at unprecedented rates and scales. It is to these pathways that we now turn.

Focusing on the kinds of pathways individuals select clarifies how observable shifts in behaviour and technological selection for adaptation under disruptive conditions illuminates perceived insecurities brought about by shocks. Water tanks, boreholes and well points signal resourcefulness and flexibility in supply. Yet there are limits to the scalable impact of private resourcefulness, especially in unequal societies. Spatially entrenched inequalities limit uptake of these capacities to an affluent constituency who were able to move beyond the water resources that the municipality was making available through its established water distribution systems. These developments have led to the creation of a new water infrastructure that has fundamentally transformed the way in which water within Cape Town is harvested and distributed. Fig. 2 charts these developments.

Fig. 2 distinguishes between conventional (centralised) distribution grids and the new assemblage where key public goods, such as water, are also secured through private actions. Two key characteristics of the emergence of the new governance assemblage are

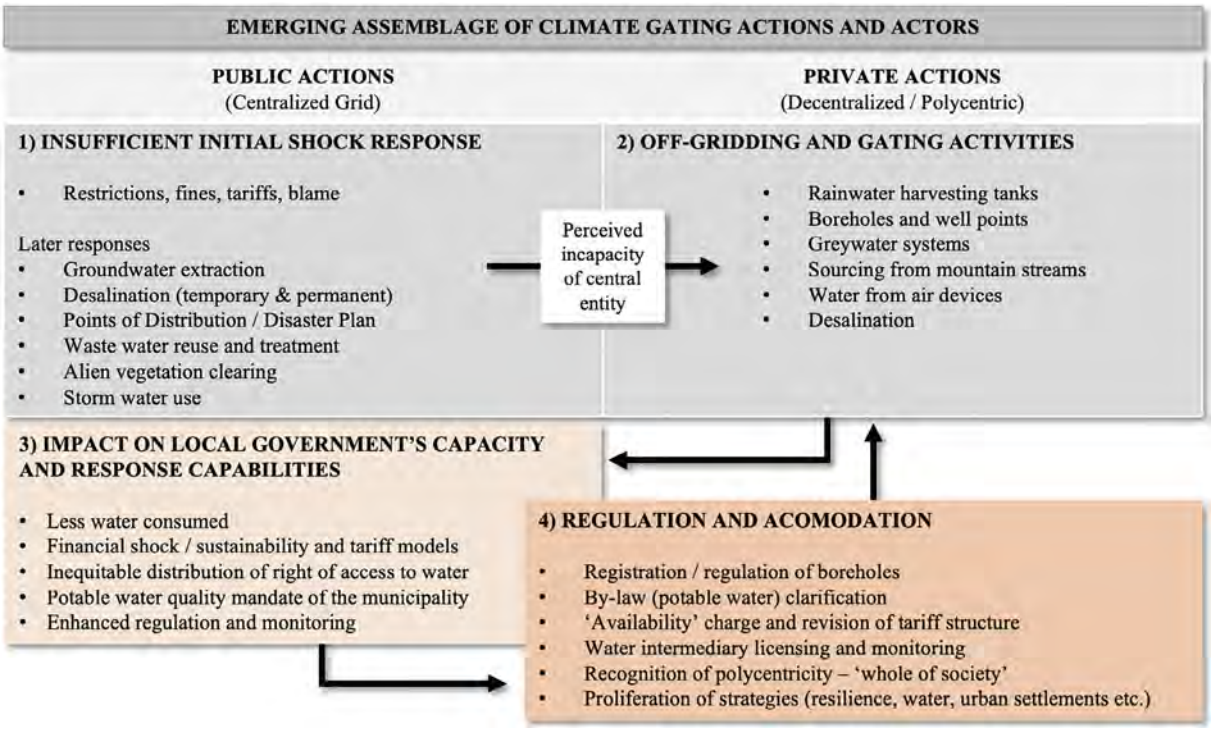

Fig. 2. Water Governance Chart.

highlighted in this figure through steps 3 and 4 of the diagram. Step 3 outlines the impact of private actions on the local municipality, before the local government was able to recognise the effect of their actions on the conventional governance arrangement, and while it was itself attempting to respond to the drought through its conventional frame and infrastructures. As less water was consumed the city's budget, in part dependent on revenues generated through water sales, was adversely affected. Simpson et al. (2019b) have described the effect this had on municipal finances and the threat it poses to cross subsidisation and the sustainability of the public entity's finance model. The 'shock within a shock' they observe has implication for planning, but also the majority of Cape Town's population who remain dependent on the grid. This new arrangement further complicates existing inequalities in water access in the city and curtailed the City's ability to deal with such stressors. Nonetheless, recognising the City's mandate to deliver potable drinking water to the city, in addition to addressing supply augmentation concerns (CoCT, 2019a), the local municipality's notable response has been to regulate.

Step 4 of Fig. 2 highlights regulatory and policy measures taken by the city to accommodate private and off-grid activities. In its communications to make people aware of the 2010 Water By-law, and its 2018 Amendment, the CoCT requires registration of boreholes and well points, "for environmental research and monitoring purposes only and not for billing" (CoCT, 2019b, p. 1). This stance indicates an acceptance by the City of these emerging water governance arrangements. However, acceptance should not be mistaken for resignation. The City has clarified its stance as the appropriate and principal water distributor within Cape Town as "a record of the amount of water used" must be kept and "no alternative water source can be used for drinking, cooking (and food preparation) or ablution (body washing), due to potential health risks" making the City's water the only lawful drinking water source; unless the entity has a 'water intermediary' licence (CoCT, 2019c, p. 7).

Further, residents were informed that they needed to "give the City two weeks' notice before planning to sink a borehole, well or well point (CoCT, 2019c, p. 8). By June 2019, Cape Town had passed nine new water regulations. The specificity of this communication programme, outlining regulatory requirements that position and curtail the potential reach of off-grid actions, highlight the importance the CoCT has placed on being able to both accommodate and manage these emerging water harvesting and distribution arrangements as the City committed itself to "promote the responsible use of rainwater, grey-water and groundwater from private borehole and well points for non-drinking purposes" (CoCT, 2019d, p. 12). In confirmation of the stance that all drinking water should come from the central grid and should recognise the imperative of keeping residents connected, in the 2019–2020 General Tariff Policy the City has included an 'availability' charge for all 'serviced' properties (CoCT, 2019e, p. 40).

Such regulatory constraints and provisions placed on off-gridding entities are seen by the City as accommodation of what they term a "whole-of-society" approach to a "water resilient city" (CoCT, 2019d, p. 29), which "will depend on the actions of all people and institutions living in the city" (CoCT, 2019d, p. i). This is a marked transition away from the governance arrangements of a traditional centralised system. Conventional municipal reticulations systems map well with centralised governance and planning with legibility, security and risk all calculated by water officials and within a stable governance and climatic system. Within such arrangements, citizens entrusted public or utility scale entities with securing adequate quality and quantity of essential goods. Together with a breakdown of trust (Ziervogel, 2019), material decentralization and the associated security provided by off-gridding, in response to the drought, has disrupted Cape Town's established water reticulation system which remains committed to 'prioritise bulk infrastructure' (CoCT, 2018a).

How the CoCT responds from here, will continue to shape the flow of water, as well as what role they might play in enhancing Cape Town's general resilience to climate related shocks. Fig. 2 suggests private climate gating activities are part of, not separate from, an emerging water governance assemblage where decentralised arrangements overlap with the actions of local government. If this 'gating' arrangement tracks what has emerged elsewhere – for example in education (Holley and Shearing, 2017), health (Hein et al., 2010) and policing (Dupont, 2017; Grabosky, 2007) – it could signal a more permanent shift towards a dual system in which the affluent become self-providers of 'club goods' (Hope, 2000) used to supplement or replace public provision (Bislev, 2004). Shopping malls, often associated with residential housing and office space, provide ubiquitous examples. In many northern hemisphere cities, these gated spaces constitute 'eco-islands' with temperate climates that shield those who have access to them from 'the elements' – snow, rain and the like – and provide their populations with carefully controlled temperatures. The same applies in areas, such as the Middle East, where outside heat often exceeds the temperature that humans can tolerate for survival. Emerging across the globe are state of the art facilities like the Biodome Office within Amazon's Seattle Spheres (Wall Street Journal, 2019), the new indoor ecological complex at Singapore's Changi Airport (Kupelian and Narishkin, 2019), Dubai's 'Sustainable City' (Diamond Developers, 2019), and South Africa's 'Steyn City' (Steyn City Properties, 2019), giving contemporary expression to what were once considered curious experimentation in the Eden Project (The Eden Project, 2019).

Likewise, scholars are exploring what new strategies best suit the needs of smart, integrated and decentralised systems that might mainstream or entrench such moves (de Graaf, 2019). These spaces, whose 'gates' filter access, constitute habitable eco-islands not unlike the earth-like islands that Elon Musk has envisaged on Mars (Petranek, 2015), as an outpost for a handful of humans. If the 'planetary boundaries' that Rockström and colleagues have identified continue to be breached (Rockström et al., 2009; Steffen et al., 2018), and large sections – perhaps all – of Earth become uninhabitable to humans and many other species (Barnosky et al., 2011), perhaps there will be no need to travel to Mars. Eco-islands, that operate within the required thresholds for human comfort and productivity may well be emerging on planet Earth, even while fears of a 'climate apartheid' and its associated unsecured harmscapes are faced by large cohorts of people in inequitable societies across the globe (Brisman et al., 2018, p. 301). 'Holocene climate pods' – such as 'refuge' cities (Pierre-Louis, 2019) – emerging within increasingly hostile Anthropocene climatic conditions may well extend existing forms of 'gating' and antecedent 'premium ecological enclaves' (Hodson and Marvin, 2010) in concert with anticipated risk megatrends facing cities (Hardy and Hauer, 2018; Laville, 2019). 'Climate gating' in response to shifting climatic regimes has arrived and is being actively pursued. Whether and how these Holocene-like islands will emerge, whether it will be possible to maintain them

and who will have access will become known as the Anthropocene Century unfolds.

5. Conclusion

Using a broadly defined notion of security, this article has provided a novel approach to understanding how societies respond to and cope with major climatic disruption. It has done so through the lens of shifts in water harvesting and distribution within the CoCT as its citizens have sought to enhance their water security. It has proposed the idea of 'climate gating' as an overarching term for the kinds of coupled off-gridding and gating responses observed in Cape Town. This extends existing analyses of how local experimentation under conditions of the disruption of essential services can reshape established governance assemblages.

A question that arises is how public decision making can, and should, respond to the shifts in governance arrangements we have identified. These shifts are challenging established conceptions of how the provision of goods such as water can, and should be provided, as well as established arrangements for doing so. Answering this question will require comparative analyses across geographic, temporal and political contexts.

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

Data set supporting Fig. 1: Rainwater harvesting tank sales data, number of registered boreholes and well points, and reduction in number of households consuming more than 20,000L per month, Cape Town, Sept 2016-April 2019 (CoCT, 2018b; Jordan, 2019; National Sales & Marketing – "X Tanks", 2018).

Month/ Year	Unit Sales (No. tanks sold over 1000 L capacity)	X Tanks Estimated Market Share	Estimated Total Industry Tank Sales	Number of households consuming over 20,000 L per month	Registered boreholes and wells
Dec-15	235	25%	940		
Jan-16	295	25%	1180		
Feb-16	387	25%	1548		
Mar-16	363	25%	1452		
Apr-16	463	25%	1852		
May-16	344	25%	1376		
Jun-16	357	30%	1190		
Jul-16	277	30%	923		
Aug-16	373	30%	1243		
Sep-16	535	30%	1783		1500
Oct-16	495	30%	1650		
Nov-16	829	30%	2763		
Dec-16	1132	35%	3234	117,000	
Jan-17	791	35%	2260		
Feb-17	1706	35%	4874		
Mar-17	2609	35%	7454		
Apr-17	1604	35%	4583		
May-17	1538	35%	4394		
Jun-17	2697	35%	7706		
Jul-17	2677	35%	7649		
Aug-17	3183	35%	9094		
Sep-17	4030	40%	10,075		
Oct-17	5149	40%	12,873		
Nov-17	6037	40%	15,093		
Dec-17	4329	40%	10,823		
Jan-18	4313	40%	10,783		
Feb-18	8010	40%	20,025	12,300	
Apr-19					26,000

References

Allan, C., Xia, J., Pahl-Wostl, C., 2013. Climate change and water security: challenges for adaptive water management. Curr. Opin. Environ. Sustain. 5, 625–632. https://doi.org/10.1016/j.cosust.2013.09.004.

Bai, X., van der Leeuw, S., O'Brien, K., Berkhout, F., Biermann, F., Brondizio, E.S., Cudennec, C., Dearing, J., Duraiappah, A., Glaser, M., Revkin, A., Steffen, W., Syvitski, J., 2016. Plausible and desirable futures in the Anthropocene: a new research agenda. Glob. Environ. Chang. 39, 351–362. https://doi.org/10.1016/j.gloenvcha.2015.09.017.

Bakker, K., Morinville, C., 2013. The governance dimensions of water security: a review the governance dimensions of water security: a review. Philos. Trans. R. Soc. A Math. Phys. Eng Sci.

Barnosky, A.D., Matzke, N., Tomiya, S., Wogan, G.O.U., Swartz, B., Quental, T.B., Marshall, C., McGuire, J.L., Lindsey, E.L., Maguire, K.C., Mersey, B., Ferrer, E.A., 2011. Has the Earth's sixth mass extinction already arrived? Nature 471, 51–57. https://doi.org/10.1038/nature09678.

Bayley, D.H., Shearing, C., 2001. The New Structure of Policing: Description, Conceptualization, and Research Agenda. U.S. Department of Justice, Washington, DC.

Berg, J., Shearing, C., 2018. Governing-through-harm and public goods policing. Ann. Am. Acad. Pol. Soc Sci in press.

Berg, J., Shearing, C., 2008. Integrated Security: Assembling Knowledges and Capacities. In: Williamson, T. (Ed.), The Handbook of Knowledge-Based Policing: Current Conceptions and Future Directions. John Wiley & Sons, Chichester, pp. 389–404.

Biermann, F., Bai, X., Bondre, N., Broadgate, W., Arthur Chen, C.T., Dube, O.P., Erisman, J.W., Glaser, M., van der Hel, S., Lemos, M.C., Seitzinger, S., Seto, K.C., 2016. Down to earth: contextualizing the anthropocene. Glob. Environ. Chang. 39, 341–350. https://doi.org/10.1016/j.gloenvcha.2015.11.004.

Bislev, S., 2004. Globalization, state transformation, and public security. Int. Polit. Sci. Rev. 25, 281–296.

Blakely, E.J., Snyder, M.G., 1997. Fortress America: Gated Communities in the United States. Brookings Institution Press, Washington D.C.

Booysen, M., Visser, M., Burger, R., 2019. Temporal case study of household behavioural response to Cape Town's "Day Zero" using smart meter data. Water Res. 149, 414–420. https://doi.org/10.1016/j.watres.2018.11.035.

Braithwaite, J., Drahos, P., 2000. Global Business Regulation. Cambridge University Press, Cambridge.

Brick, K., De Martino, S., Visser, M., 2018. Behavioural Nudges for Water Conservation: Experimental Evidence from Cape Town. Draft Working Paper. Cape Town. https://doi.org/10.13140/RG.2.2.25430.75848.

Brisman, A., South, N., Walters, R., 2018. Climate Apartheid and Environmental Refugees. In: Carrington, K., Hogg, R., Scott, J., Sozzo, M. (Eds.), The Palgrave Handbook of Criminology and the Global South. Springer International Publishing, Cham, pp. 301–321. https://doi.org/10.1007/978-3-319-65021-0_16.

Chapman, A., 2014. The impact of reliance on private sector health services on the right to health. Heal. Hum Rights 16, 122–133.

Clarvis, M.H., Bohensky, E., Yarime, M., 2015. Can resilience thinking inform resilience investments? learning from resilience principles for disaster risk reduction. Sustainability 7, 9048–9066. https://doi.org/10.3390/su7079048.

CoCT, 2019a. Cape Town Water Strategy (2019): Our shared water future [WWW Document]. City Cape T. URL https://www.preventionweb.net/files/63935_capetowndraftwaterstrategy2019publi.pdf.

CoCT, 2019b. Register a borehole [WWW Document]. City Cape T. Media Release. URL http://www.capetown.gov.za/City-Connect/Register/Water-and-sanitation/Register-a-borehole (accessed 4.9.19).

CoCT, 2019c. Summary Guide of the Water By-law [WWW Document]. URL http://resource.capetown.gov.za/documentcentre/Documents/Procedures%2C guidelines and regulations/Water By-law _summary_guideline_A5.pdf.

CoCT, 2019d. Draft Cape Town Water Strategy: Our shared water future [WWW Document]. City Cape T. URL https://www.preventionweb.net/files/63935_capetowndraftwaterstrategy2019publi.pdf.

CoCT, 2019e. 2019/2020 General Tariff Policies: Annex 7 [WWW Document]. URL http://resource.capetown.gov.za/documentcentre/Documents/Financial documents/Ann7_2019-20_General Tariff Policies.pdf.

CoCT, 2018a. Resilient Cape Town: Preliminary Resilience Assessment [WWW Document]. City Cape T. URL http://resource.capetown.gov.za/documentcentre/Documents/City research reports and review/CCT PreliminaryResilienceAssessment.pdf (accessed 10.9.18).

CoCT, 2018b. Water dashboard reveals alarming high consumption trend [WWW Document]. URL http://www.capetown.gov.za/Media-and-news/Water dashboard reveals alarming high consumption trend.

CoCT, 2017. City moves to restrict high consumption households with water management devices [WWW Document]. City Cape T. Local Gov. Munic. URL http://www.capetown.gov.za/Media-and-news/City moves to restrict high consumption households with water management devices.

Crutzen, P.J., Stoermer, E., 2000. The 'Anthropocene'. IGBP NewsL 41, 17–18.

de Graaf, F., 2019. New Strategies for Smart Integrated Decentralised Energy Systems [WWW Document]. Netherlands Enterp, Agency https://www.metabolic.nl/publications/side-systems/.

De Lille, P., 2017a. Water Resilience: A Heightened Approach to Avoiding Water Shortages and Achieving Long-term Water Security. Office of the Mayor of City of Cape Town Local Government Municipality, Cape Town.

De Lille, P., 2017b. Drought Crisis: Moving Forward Together. Office of the Mayor of City of Cape Town Local Government Municipality, Cape Town.

Diamond Developers, 2019. The Sustainable City [WWW Document]. City Dubai. URL https://www.thesustainablecity.ae/book-a-tour/.

Dryzek, J.S., 2016. Institutions for the anthropocene: governance in a changing earth system. Br. J. Polit. Sci. 46, 937–956. https://doi.org/10.1017/S0007123414000453.

Dubé, L., Addy, N.A., Blouin, C., Drager, N., 2014. From policy coherence to 21st century convergence: a whole-of-society paradigm of human and economic development. Ann. N. Y. Acad. Sci. 1331, 201–215. https://doi.org/10.1111/nyas.12511.

Dupont, B., 2017. Bots, cops, and corporations: on the limits of enforcement and the promise of polycentric regulation as a way to control large-scale cybercrime. Crime Law Soc. Chang. 67, 97–116. https://doi.org/10.1007/s10611-016-9649-z.

Enqvist, J.P., Ziervogel, G., 2019. Water governance and justice in Cape Town: an overview. Wiley Interdiscip. Rev. Water e1354. https://doi.org/10.1002/wat2.1354.

Falkenmark, M., 2013. Growing water scarcity in agriculture : future challenge to global water security. Philos. Trans. R. Soc. 371https://doi.org/10.1098/rsta.2012.0410. 20120410.

Geels, F., Raven, R., 2006. Non-linearity and expectations in niche-development trajectories: ups and downs in Dutch biogas development (1973–2003). Technol. Anal. Strateg. Manag. 18, 375–392. https://doi.org/10.1080/09537320600777143.

Grabosky, P.N., 2007. Private sponsorship of public policing. Police Pract. Res. 8, 5–16.

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

Hardy, R.D., Hauer, M.E., 2018. Social vulnerability projections improve sea-level rise risk assessments. Appl. Geogr. 91, 10–20. https://doi.org/10.1016/j.apgeog.2017.12.019.

Harrington, C., Shearing, C., 2017. Security in the Anthropocene: Reflections on Safety and Care. transcript Verlag, Bielefeld.

Hein, Wolfgang, Burris, S., Shearing, C., 2010. Conceptual models for global health governance. In: Buse, K., Hein, W., Drager, N. (Eds.), Making Sense of Global Health Governance: A Policy Perspective. Palgrave Macmillan, Basingstoke, pp. 72–98.

Hodson, M., Marvin, S., 2010. Urbanism in the Anthropocene: ecological urbanism or premium ecological enclaves? City 14, 299–313. https://doi.org/10.1080/13604813.2010.482277.

Holley, C., Shearing, C., 2017. A Nodal Perspective of Governance : Advances in Nodal Governance Thinking, in: Regulations, Institutions and Networks. pp. 1–20. https://doi.org/10.22459/RT.02.2017.10.

Hope, T., 2000. Inequality and the clubbing of private security. In: Armstrong, J.B., Edwards, S.H., Roberson, H.B., Williams, R.Y. (Eds.), Teaching the American Civil Rights Movement: Freedom's Bittersweet Song. Routledge, Oxon and New York, pp. 83–106.

Hursh, D., 2005. Neo-liberalism, markets and accountability: Transforming education and undermining democracy in the United States and England. Policy Futur. Educ. 3, 3–15.

Jaglin, S., 2013. Urban energy policies and the governance of multilevel issues in Cape Town. Urban Stud. 51, 1394–1414.

Jepson, W., Budds, J., Eichelberger, L., Harris, L., Norman, E., O'Reilly, K., Pearson, A., Shah, S., Shinn, J., Staddon, C., Stoler, J., Wutich, A., Young, S., 2017. Advancing human capabilities for water security: a relational approach. Water Secur. 1, 46–52. https://doi.org/10.1016/j.wasec.2017.07.001.
Jordan, B., 2019. Cape Town's water plans go underground: Number of boreholes soars as Cape Town eyes groundwater [WWW Document]. The Sunday Times. URL https://www.timeslive.co.za/sunday-times/news/2019-04-07-cape-towns-water-plans-go-underground/ (accessed 4.7.19).
Kossin, J.P., 2018. A global slowdown of tropical-cyclone translation speed. Nature 558, 104–108. https://doi.org/10.1038/s41586-018-0158-3.
Kupelian, K., Narishkin, A., 2019. Inside the $1.3 billion complex at Singapore's Changi Airport [WWW Document]. Bus. Insid. URL https://www.businessinsider.com/singapore-airport-complex-changi-airport-indoor-waterfall-mall-2019-4?IR=T (accessed 5.22.19).
Laville, S., 2019. Climate crisis: flooding threat 'may force UK towns to be abandoned' [WWW Document]. Guard. URL https://www.theguardian.com/environment/2019/may/09/climate-crisis-flooding-threat-may-force-uk-towns-to-be-abandoned (accessed 5.9.19).
Luker, E., Harris, L.M., 2018. Developing new urban water supplies: investigating motivations and barriers to groundwater use in Cape Town. Int. J. Water Resour. Dev. 00, 1–21. https://doi.org/10.1080/07900627.2018.1509787.
Madonsela, B., Koop, S., Van Leeuwen, K., Carden, K., 2019. Evaluation of water governance processes required to transition towards Water Sensitive Urban Design – an indicator assessment approach for the City of Cape Town. Water (Switzerland) 11, 14. https://doi.org/10.3390/w11020292.
McClelland, C., 2019. Growthpoint taps desalination to ensure water supply [WWW Document]. Moneyweb. URL https://www.moneyweb.co.za/investing/property/growthpoint-taps-desalination-to-ensure-va-water-supply/ (accessed 4.9.19).
Milly, P.C.D., Betancourt, J., Falkenmark, M., Hirsch, R.M., Kundzewicz, Z.W., Lettenmaier, D.P., Stouffer, R.J., 2008. Stationarity is dead: whither water management? Science (80-) 319, 573–574. https://doi.org/10.1126/science.1151915.
Morello-Frosch, R., Pastor, M., Sadd, J., 2001. Environmental justice and southern California's "riskscape" the distribution of air toxics exposures and health risks among diverse communities. Urban Aff. Rev. 36, 551–578. https://doi.org/10.1177/10780870122184993.
Mustafa, D., 2005. The production of an urban hazardscape in Pakistan: Modernity, vulnerability, and the range of choice. Ann. Assoc. Am. Geogr. 95, 566–586. https://doi.org/10.1111/j.1467-8306.2005.00475.x.
National Sales & Marketing – "X Tanks," 2018. Interview with "X Tanks" National Sales & Marketing Manager (27 March 2018).
O'Malley, P., 2003. Governable catastrophes: a comment on Bougen. Econ. Soc. 32, 275–279. https://doi.org/10.1080/0308514032000073437.
Ogden, L., Heynen, N., Oslender, U., West, P., Kassam, K.A., Robbins, P., 2013. Global assemblages, resilience, and Earth Stewardship in the Anthropocene. Front. Ecol. Environ. 11, 341–347. https://doi.org/10.1890/120327.
Ostrom, E., 2010. Polycentric systems for coping with collective action and global environmental change. Glob. Environ. Chang. 20, 550–557.
Pace, A., 2019. Luxury Cape Town hotel goes off water grid [WWW Document]. Capetownetc. URL https://www.capetownetc.com/cape-town/luxury-cape-town-hotel-goes-off-water-grid/ (accessed 4.10.19).
Palm, K., 2018. Businesses cash in on CT water crisis [WWW Document]. Eye Witn. News. URL http://ewn.co.za/2018/01/26/businesses-cash-in-on-ct-water-crisis (accessed 3.15.18).
Petranek, S., 2015. How We'll Live on Mars. Simon and Schuster, New York.
Poirier, A., Dubé, L., Drager, N., Addy, N.A., Blouin, C., 2014. Whole-of-society approach for public health policymaking: a case study of polycentric governance from Quebec, Canada. Ann. N. Y. Acad. Sci. 1331, 216–229. https://doi.org/10.1111/nyas.12503.
Pretorius, J., 2018. Why treating water scarcity as a security issue is a bad idea [WWW Document]. Conversat. URL https://theconversation.com/why-treating-water-scarcity-as-a-security-issue-is-a-bad-idea-90951 (accessed 7.22.19).
Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J.A., 2009. A safe operating space for humanity. Nature 461, 472–475. https://doi.org/10.1038/461472a.
Rodina, L., 2019. Planning for water resilience: competing agendas among Cape Town's planners and water managers. Environ. Sci. Policy 99, 10–16. https://doi.org/10.1016/j.envsci.2019.05.016.
Romero-Lankao, P., Gnatz, D.M., 2016. Conceptualizing urban water security in an urbanizing world. Curr. Opin. Environ. Sustain. 21, 45–51. https://doi.org/10.1016/j.cosust.2016.11.002.
Shearing, C., 2015. Criminology and the Anthropocene. Criminol. Crim. Justice 15, 255–269.
Shearing, C., Stenning, P.C., 1983. Private security and its implications: a North American perspective. In: Rees, A. (Ed.), Policing and Private Security. Australian Institute of Criminology, Canberra, pp. 16–44.
Simpson, N.P., 2019. Accommodating landscape-scale shocks: Lessons on transition from Cape Town and Puerto Rico. Geoforum 102, 226–229. https://doi.org/10.1016/j.geoforum.2018.12.005.
Simpson, N.P., Shearing, C., Dupont, B., 2019a. When Anthropocene shocks contest conventional mentalities: a case study from Cape Town. Clim. Dev. https://doi.org/10.1080/17565529.2019.1609402.
Simpson, N.P., Simpson, K.J., Shearing, C.D., Cirolia, L.R., 2019b. Municipal finance and resilience lessons for urban infrastructure management: a case study from the Cape Town drought. Int. J. Urban Sustain. Dev. 00, 1–20. https://doi.org/10.1080/19463138.2019.1642203.
Srinivasan, V., Konar, M., Sivapalan, M., 2017. A dynamic framework for water security. Water Secur. 1, 12–20. https://doi.org/10.1016/j.wasec.2017.03.001.
Stats-SA, 2017. Living Conditions Survey (2014/2015) [WWW Document]. URL http://www.statssa.gov.za/publications/P0310/P03102014.pdf.
Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C.P., Barnosky, A.D., Cornell, S.E., Crucifix, M., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R., Schellnhuber, H.J., 2018. Trajectories of the Earth System in the Anthropocene. Proc. Natl. Acad. Sci. U.S.A. 115, 8252–8259. https://doi.org/10.1073/pnas.1810141115.
Steyn City Properties, 2019. Steyn City [WWW Document]. URL https://www.steyncity.co.za/ (accessed 7.22.19).
Subramanian, M., 2019. Anthropocene now: influential panel votes to recognize Earth's new epoch. Nature. https://doi.org/10.1038/d41586-019-01641-5.
The Eden Project, 2019. The Eden Project [WWW Document]. Eden Proj. URL https://www.edenproject.com/eden-story/eden-timeline (accessed 5.22.19).
The Rockefeller Foundation and ARUP, 2016. City Resilience Index: understanding and measuring city resilience [WWW Document]. Rockefeller Found, ARUP https://assets.rockefellerfoundation.org/app/uploads/20160201132303/CRI-Revised-Booklet1.pdf.
Valverde, M., 2014. Studying the governance of crime and security: space, time and jurisdiction. Criminol. Crim. Justice 14, 379–391.
Van der Heijden, T., 2013. Why the Lights went Out: Reform in the South African Energy Sector. University of Cape Town: Graduate School of Development Policy and Practice, Cape Town.
Visser, W.P., 2018. A perfect storm: the hydropolitics of Cape Town's water crisis. J. Transdiscipl. Res. South. Africa 14, 1–9. https://doi.org/10.4102/td.v14i1.567.
Vob, J.-P., Schroth, F., 2019. Experimentation: the politics of innovation and learning in polycentric governance. In: Jordan, A., Huitema, D., van Asselt, H., Forster, J. (Eds.), Governing Climate Change. Cambrdige University Press, Cambridge, pp. 99–116 https://doi.org/10.1017/9781108284646.002.
Wall Street Journal, 2019. Inside Amazon's Spheres, the Biodome Office in Seattle [WWW Document]. YouTube. URL https://www.youtube.com/watch?v=MRwLyefu0G0 (accessed 5.28.19).
Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A.G., De Souza Dias, B.F., Ezeh, A., Frumkin, H., Gong, P., Head, P., Horton, R., Mace, G.M., Marten, R., Myers, S.S., Nishtar, S., Osofsky, S.A., Pattanayak, S.K., Pongsiri, M.J., Romanelli, C., Soucat, A., Vega, J., Yach, D., 2015. Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health. Lancet 386, 1973–2028. https://doi.org/10.1016/S0140-6736(15)60901-1.
Wise, R.M., Fazey, I., Stafford Smith, M., Park, S.E., Eakin, H.C., Archer Van Garderen, E.R.M., Campbell, B., 2014. Reconceptualising adaptation to climate change as part of pathways of change and response. Glob. Environ. Chang. 28, 325–336. https://doi.org/10.1016/j.gloenvcha.2013.12.002.
Wolski, P., 2017. How severe is this drought, really? [WWW Document]. Clim. Syst. Anal. Gr. URL http://www.csag.uct.ac.za/2017/08/28/how-severe-is-this-drought-really/ (accessed 7.22.19).
Wolski, P., Hewitson, B., Jack, C., 2017. Why Cape Town's drought was so hard to forecast [WWW Document]. Conversat. URL https://theconversation.com/why-cape-towns-drought-was-so-hard-to-forecast-84735.

Woodward, A., 2019. Climate change: disruption, risk and opportunity. Glob. Trans. 1, 44–49. https://doi.org/10.1016/j.glt.2019.02.001.
World Bank, 2018. Toolkit for Climate Adaptation in Cities [WWW Document]. URL http://www-esd.worldbank.org/citiesccadaptation/resourcesTC.html (accessed 1.3.18).
Yazdani, A., Otoo, R.A., Jeffrey, P., 2011. Resilience enhancing expansion strategies for water distribution systems: a network theory approach. Environ. Model. Softw. 26, 1574–1582. https://doi.org/10.1016/j.envsoft.2011.07.016.
Zajda, J., 2006. Introduction: decentralisation and privatisation in education: the role of the state. In: Decentralisation and Privatisation in Education. Springer, Dordrecht, pp. 3–27.
Ziervogel, G., 2019. Unpacking the Cape Town drought: Lessons learnt [WWW Document]. URL https://www.africancentreforcities.net/wp-content/uploads/2019/02/Ziervogel-2019-Lessons-from-Cape-Town-Drought_A.pdf (accessed 7.22.19).
Ziervogel, G., Shale, M., Du, M.L., 2010. Climate change adaptation in a developing country context: the case of urban water supply in Cape Town. Climate Develop. 2 (2), 94–110. https://doi.org/10.3763/cdev.2010.0036.