Transitioning to CLEAN WATER AND SANITATION

Guéladio Cissé (Ed.)

Transitioning to
Clean Water and Sanitation

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Guéladio Cissé is a Professor of Sanitary Engineering and Environmental Epidemiology. He is also Head of the Ecosystem Health Sciences Unit in the Department of Epidemiology and Public Health of the Swiss Tropical and Public Health Institute (Swiss TPH), University of Basel, Switzerland. Before joining Swiss TPH in 2009, he worked for more than 20 years based in West Africa. Here he held positions such as Head of the National Service for Hygiene and Sanitation in the Ministry of Health in Mauritania; Professor and Head of the Sanitary Engineering Department in an inter-African states engineering school in Burkina Faso; Coordinator of Regional Research Programs on Global Change and Health Linkages and Director of the Swiss Center for Scientific Research (CSRS) in Côte d'Ivoire. For more than 25 years, he has been engaged in eco-epidemiology research, exploring links between water quality, environmental pollution, climate change and environment-sensitive diseases. He teaches and directs research on climate change and health, disasters and public health, and the Sustainable Development Goals (SDGs). He is the author of several publications, has supervised the work of several young African researchers and has contributed to many international conferences and panels of experts on water, environment, ecosystems, climate change, health and SDGs. He is currently a member of the Intergovernmental Panel on Climate Change (IPCC) Working Group II on "Impacts, Adaptation and Vulnerability" for the IPCC Sixth Assessment Report (AR6), for which there is a call for further efforts in all sectors for transition and transformation. He was a Co-Chair of the 5th World Sustainability Forum organized by MDPI in 2015, among several other contributions to international conferences and initiatives on the topic of the SDGs, including this SDG Book Series *"Transitioning to Sustainability".*

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Abstracts

Preface to Transitioning to Clean Water and Sanitation

by Guéladio Cissé

The right to water is now widely recognized as a human right both under the United Nations human rights system as well as the African regional human rights system. However, the right to water in Zambia is not expressly recognized in law. Nevertheless, this does not shield the Zambian state from it's obligations under international human rights law to uphold the right to water. As a binding human right, states are under a duty to ensure their people enjoy the right to water. This chapter is a case comment. It comments on the challenge of enforcing the right to water of Zambian communities living in the vicinity of the mine owned by Vedanta PLC in Zambia, where sources of water have been habitually polluted. The chapter proceeds by first grounding the right to water in international human rights law, that is, both the United Nations human rights system and the African regional human rights system. It then proceeds by focusing on the subject of the case review, that is, the cases which affected communities brought to the courts to vindicate their right to water. The court cases are based on the incessant pollution of the river from which the community drew water for drinking and domestic use by Konkola Copper Mines (KCM), a Zambian mining company in which Vedanta PLC has a controlling stake. The review of court cases demonstrates in miniature form the practical and legal challenges poor people face in trying to have their right to water enforced. This is compounded when the perpetrator is a mining conglomerate with strong influence on the political elite. Ultimately, the case comments demonstrate how the domestic legal system is unresponsive to the needs of the victims of water pollution.

Water Exchange and Wastewater Reuse to Achieve SDG 6: Learning from Agriculture and Urban-Tourism Coexistence in Benidorm (Spain)

by Sandra Ricart, Rubén Villar-Navascués and Antonio M. Rico-Amorós

Water exchange among agricultural and urban-tourism water demand and wastewater reuse could contribute to ensuring the SDGs. Benidorm's experience (South-Eastern Spain), a location suffering from water scarcity risk, is presented to

highlight key driving factors to be considered when promoting water exchange and wastewater reuse between confronted water demands. Semi-structured interviews with the Marina Baja Water Consortium (urban and tourism water demand) and the Canal Bajo del Algar irrigation community (agricultural water demand) have been conducted. Thematic analysis has been carried out to highlight water management, water quality, and water charging as the three main driving factors when promoting water exchange and wastewater reuse between agricultural and urban-tourist activities. Additionally, eight sub-themes have been identified: infrastructures, water exchange protocol activation, water concession, water quality standards, water contamination sources, control mechanisms, pollution pays principle and the recovery cost, and water pricing—costs and incentives. The irrigation community and the water consortium perceive some questions differently, such as the lack of agronomic criteria to activate the water exchange, the occasional lack of accomplishment of water quality standards, or how to achieve the polluter pays principle and the recovery cost. However, water exchange and wastewater reuse are considered mechanisms to ensure the viability of agricultural and urban-tourist activities by increasing water use efficiency and supply (SDG target 6.4). Furthermore, the obtained results highlight how facing water scarcity in semi-arid regions where conflicting water uses coexist can be governance-based rather than technology-based, as demonstrated by the agreements between the water consortium and the irrigation community. This new perspective is an example of desirable transition and transformation duality towards sustainability considering stakeholders' learning and knowledge integration.

Transitioning to SDG 6: Climate Change Influence on Clean Water and Sanitation in Nepal

by Subodh Sharma, Sudan Raj Panthi, Raja Ram Pote Shrestha, Manish Baidya and Prativa Poudel

Climate change is among the critical global challenges of the twenty-first century. In this context, Sustainable Development Goal 6 (SDG 6) appears ambitious for water and sanitation. Transitioning to SDGs is coupled with various factors that may prevent the achievement of these goals. This chapter discusses the various impacts of climate change on water and sanitation with evidence from a developing country, Nepal. Nepal being one of the most vulnerable countries in terms of climate change, where almost every sector, including water, sanitation, and hygiene (WASH), is impacted by climate change. The impact on the WASH sector is evident either in the form of infrastructural damages or reduced water quantity or quality at the source leading to compromised hygiene. Several climate change adaptation practices have been adopted to reduce the impact of climate change on water supply and sanitation, but those locally adapted practices are not necessarily resilient. Considerations of climate-resilient development in the WASH sector are vital to successfully attain SDG 6 while acting on the transition phase of SDGs.

Transitioning to Low-Carbon Drinking Water and Sanitation Services: An Assessment of Emission and Real Water Losses Efficiency of Water Utilities

by Jayanath Ananda

The right to water is now widely recognized as a human right both under the United Nations human rights system as well as the African regional human rights system. However, the right to water in Zambia is not expressly recognized in law. Nevertheless, this does not shield the Zambian state from its obligations under international human rights law to uphold the right to water. As a binding human right, states are under a duty to ensure their people enjoy the right to water. This chapter is a case comment. It comments on the challenge of enforcing the right to water of Zambian communities living in the vicinity of the mine owned by Vedanta PLC in Zambia, where sources of water have been habitually polluted. The chapter proceeds by first grounding the right to water in international human rights law, that is, both the United Nations human rights system and the African regional human rights system. It then proceeds by focusing on the subject of the case review, that is, the cases which affected communities brought to the courts to vindicate their right to water. The court cases are based on the incessant pollution of the river from which the community drew water for drinking and domestic use by Konkola Copper Mines (KCM), a Zambian mining company in which Vedanta PLC has a controlling stake. The review of court cases demonstrates in miniature form the practical and legal challenges poor people face in trying to have their right to water enforced. This is compounded when the perpetrator is a mining conglomerate with strong influence on the political elite. Ultimately, the case comments demonstrate how the domestic legal system is unresponsive to the needs of the victims of water pollution.

The Challenge of Enforcing the Right to Water: The Case of the Vedanta PLC Mining Conglomerate in Zambia

by O’Brien Kaaba

The right to water is now widely recognized as a human right both under the United Nations human rights system as well as the African regional human rights system. However, the right to water in Zambia is not expressly recognized in law. Nevertheless, this does not shield the Zambian state from it’s obligations under international human rights law to uphold the right to water. As a binding human right, states are under a duty to ensure their people enjoy the right to water. This chapter is a case comment. It comments on the challenge of enforcing the right to water of Zambian communities living in the vicinity of the mine owned by Vedanta PLC in Zambia, where sources of water have been habitually polluted. The chapter proceeds by first grounding the right to water in international human rights law, that is, both the United Nations human rights system and the African regional human rights system. It then proceeds by focusing on the subject of the case review, that is, the cases which affected communities brought to the courts to vindicate their right to water. The court cases are based on the incessant pollution of the river from which the community drew water for drinking and domestic use by Konkola Copper Mines (KCM), a Zambian mining company in which Vedanta PLC has a controlling stake. The review of court cases demonstrates in miniature form the practical and legal challenges poor people face in trying to have their right to water enforced. This is compounded when the perpetrator is a mining conglomerate with strong influence on the political elite. Ultimately, the case comments demonstrate how the domestic legal system is unresponsive to the needs of the victims of water pollution.

Preface to Transitioning to Clean Water and Sanitation

Guéladio Cissé

1. Introduction

The Sustainable Development Goals (SDGs) include one goal (SDG 6) dedicated to Water, Sanitation and Hygiene (SDG 6 or SDG WASH)), which illustrates the vital role of this sector globally for a better future (Requejo-Castro et al. 2020). SDG 6 is connected to almost all the other SDGs (UN 2020). The UN Special report 2020 highlights that progress has been slow on many SDGs and that the most vulnerable people and countries continue to suffer the most (UN 2020). The 2020 COVID-19 pandemic and its unprecedented multidimensional crisis are further challenging the achievement of the SDGs (Macht et al. 2020; Pal and Pal 2021).

Five years after 2015, the world entered the decade before 2030. The new shock with the COVID-19 crisis will make the challenges to achieve the goals even harder for all the systems, notably for the water, sanitation and health systems. COVID-19 further emphasized that it is essential to ensure clean water, improved sanitation and proper hygiene conditions for better protection of health in all parts of the world (Armitage and Nellums 2020). This understanding and awakened awareness could lead to a better political goodwill to invest more in this sector.

Following the 2021 report of the World Health Organization (WHO) and the United Nations' Children and Women Fund (UNICEF) Joint Monitoring Program (JMP) on Water, Sanitation and Hygiene, in 2020, 2 billion people lacked safely managed services (WHO and UNICEF 2021). This includes 1.2 billion people with basic services, 282 million with limited services, 367 million using unimproved sources, and 122 million drinking surface water. At current rates of progress, the world will only reach 81% coverage for safe drinking water by 2030, leaving 1.6 billion people without safely managed services.

For sanitation, in 2020, 3.6 billion people lacked safely managed services, including 1.9 billion people with basic services, 580 million with limited services, 616 million using unimproved facilities, and 494 million practicing open defecation. At current rates of progress, the world will only reach 67% coverage for sanitation by 2030, leaving 2.8 billion people without safely managed services (WHO and UNICEF 2021).

For hygiene, in 2020, 2.3 billion people lacked basic services, including 670 million people with no handwashing facilities at all. Over half of these people (374 million) lived in fragile contexts. At current rates of progress, the world will only reach 78% coverage in 2030, leaving 1.9 billion people without basic services (WHO and UNICEF 2021).

Climate change has already shown huge consequences on water and sanitation systems through changes in temperature and rainfall and effects of extreme events such as droughts and floods, and this is likely to increase in the future (Brubacher et al. 2020; Cissé 2019; Musacchio et al. 2021; Sherpa et al. 2014; Suk et al. 2020).

Transition is a key concept that will be essential for the level of action needed to achieve the SDGs in a post-COVID-19 era. The SDGs are complex and their implementation is showing a number of important challenges. To achieve the goals, they call for an effective transition. Efforts and capacities to transition are inequitably distributed across the world. Developed countries will certainly make more rapid progress than less developed countries. As the challenges and the capacities are different between these categories, it will be of most interest to get some examples on the challenges and efforts for transitioning on different continents, e.g., developed countries like Europe or Australia vs. in low- and middle- income countries (LMICs) like Asia and Africa. It was in the aim of this edition to get examples from these categories.

We are happy to be able to present, in this special book on *Transitioning to Clean Water and Sanitation*, four selected contributing papers elaborating situations and cases from Europe (Spain), Oceania (Australia), Africa (Zambia) and Asia (Nepal). These interesting papers will contribute to our better understanding of how transitions are or should be underway in such different socio-economic, physical and cultural contexts for adapting water and sanitation systems to the projected impacts of climate change. Each paper highlights the challenges and indicates a way forward.

2. Highlights

2.1. Concepts

The concepts of transition and transformation are interconnected. The transition in systems will take place through processes of transformation. The IPCC, particularly in the recently released Special Reports (IPCC 2018, 2019a, 2019b), provides further clarifications and definitions about system transitions, particularly for the climate action and solution space. Following IPCC, transition is “the process of changing (the system in focus) from one state or condition to another in a given period of time”. This “another state or condition” should be toward or ensuring sustainability, as well as a fairer balance between different dimensions. It requires more than technological change, i.e., change also on social and economic factors. These shifts and efforts depend on all systems and the moves should happen at all levels: by state, public and private actors, cities, regions, individuals and communities.

For water and sanitation systems, there is a need for adequate quality and sufficient quantity of water to ensure effective environmental health for better health and wellbeing for ecosystems and people (Daniell et al. 2015; Cissé 2019). Water systems are particularly vulnerable to population growth, uncontrolled urbanization and extreme climate change events. There is an urgent need for transitions in water systems to face these challenges. Transitions in water and sanitation are already happening but should further consider both mitigation and adaptation options and actions, and their interconnections in the perspective of climate-related projected risks. This entails a better understanding of the complex interrelations between several dimensions. Enabling conditions for system transitions include finance, technological innovation, strengthening policy instruments, institutional capacity, multilevel governance, economics, and changes in human behavior and lifestyles. The traditional management of water systems is insufficient and a paradigm shift toward transitioning is needed. This means that transitioning requires more integrated, adaptive and sustainable configurations in water management (Daniell et al. 2015).

2.2. Case Studies

Sandra Ricart et al., from Europe, (Chapter 1) highlights that a better integration of non-conventional water resources is among the strategies for transitioning. The paper highlights how water management, water quality, and water charging are the three main issues to be addressed when promoting water exchange and non-conventional water resource use. The case study focuses on links between agricultural and urban–tourist activities and supports the call for approaches and actions that should combine Targets 6.3 (improve water quality, wastewater, and safe reuse), 6.4 (increase water-use efficiency and ensure freshwater supplies), 6.5 (integrated water resources management), and 6.b (participation in water and sanitation management).

Jayanath Ananda, from Australia, (Chapter 2) highlights that, globally, the water sector's greenhouse gas (GHG) emission contribution is equivalent to 20% of the sum of committed reductions by all countries in the Paris Agreement. Most reported water sector GHG emissions are still energy related and they exclude emissions from non-energy related sources, such as methane and nitrous oxide from wastewater treatment. The case study highlights the challenges for controlling emissions and calls upon water utilities for profound transformations that need to occur at three different levels (the global, national and water utility level).

Subodh Sharma et al., from Asia, (Chapter 3) highlights that Nepal is the fourth most vulnerable country with regard to climate change challenges. While the mismatch between the accessibility and the functionality of WASH facilities is still important, Nepal is regularly disrupted by extreme climate change events. This has an impact on various public health issues. Drying up of water sources and water contamination due to temperature rise and water-related disasters are among the challenges in a mountainous country. The authors call upon rapid transitions and transformations in water and sanitation management systems to achieve the targets SDG 6.1 and SDG 6.2.

O'Brien Kaaba, from Africa, (Chapter 4) highlights how neighboring poor and vulnerable communities' water systems can be affected by extractive industries. It explores how, from the perspective of water as a human right, the local level actors can struggle with the defense of their rights to protect their water systems from pollutant activities. Without clean and adequate water, the rights to any high standard of physical and mental health could not be achieved. The case study highlights the contamination of water systems by a large scale mining of copper in a region that faced a lack of systemic enforcement of the local law, a lack of easy and clear mechanisms to fight for the people's rights, and an insufficient capacity and inadequately oriented justice system. The chapter holds a wakeup call that transitions and transformations at the level of justice systems is an important part of enabling conditions to ensure the protection of water quality for all, particularly for the poor.

3. Conclusions

The case studies have shown an interesting complementarity in covering different aspects that are all part of what transition means for water and sanitation systems. Be it in developed countries or in developing countries, integrated water management and a stronger investment in environmental health are necessary and this requires a paradigm shift to mainstreaming "transition and transformation" at all levels.

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Water Exchange and Wastewater Reuse to Achieve SDG 6: Learning from Agriculture and Urban-Tourism Coexistence in Benidorm (Spain)

Sandra Ricart, Rubén Villar-Navascués and Antonio M. Rico-Amorós

1. Introduction

The mismatch between water demand and availability across temporal and geographical scales is one of the key challenges to be solved to guarantee sustainable development (Knieper and Pahl-Wostl 2016; Bertule et al. 2018). Additionally, shifts in precipitation patterns and the occurrence of extreme weather events driven by climate change, such as droughts, heatwaves, or floods, will likely lead to significant changes in water resource availability and quality standards (AghaKouchak et al. 2020; Cramer et al. 2018). In this context, ensuring universal and equitable access to drinking water and sanitation has been appointed as the sixth Sustainable Development Goal (SDG6) (Adshead et al. 2019). In addition to the leading global targets, which focus on achieving access to water and sanitation and the reduction in water pollution through improving wastewater treatment (targets 6.1, 6.2, and 6.3), the SDG6 also focus on the increase in water use efficiency and on ensuring a sustainable water supply to address and reduce water scarcity (target 6.4); the implementation of integrated water resources management at all levels (6.5); and the support and strengthening of local stakeholders to improve water and sanitation management (Mainali et al. 2018).

To achieve some of these targets, water exchange is considered an exceptional opportunity for cooperation between stakeholders' interests. At the same time, reclaimed water use has been raised as a mechanism to overcome water scarcity challenges and future water shortages in arid and semi-arid regions (Aleisa and Al-Zubari 2017; Perry and Praskievicz 2017; Reznik et al. 2019). Both mechanisms are especially relevant in those regions in which urban-tourist and agricultural users coincide, where water disputes and conflicts between users may appear (Ortega and Iglesias 2009; Baldino and Saurí 2018; Ricart and Rico 2019). Although agriculture is a key player for achieving SDG 6, as it is by far is the largest water consumer, accounting for 70% of annual water withdrawals globally (Norton-Brandao et al.

2013), in some specific contexts, urban and tourist development may represent a large part of the water demand at local and regional scales (Dinar et al. 2019; Mekonnen and Hoekstra 2016). Furthermore, tourism sector activities, which generally concentrate on those driest seasons and warmest regions, coexist with other confronted water demands (agriculture) and requirements (environment) during water scarcity periods (Sun and Hsu 2018). In rural contexts, irrigation has been developed through freshwater water rights. However, urban-tourism activities have been mainly promoted without policies or strategies for ensuring water supply, which brings extra pressure to local and regional water resources, particularly in coastal regions where seasonal water use is relevant (Gössling 2015).

On the one hand, the implementation of water exchange agreements requires establishing a good water governance framework, which is an essential pillar for implementing SDG 6, considering stakeholders' individual and everyday water needs (Megdal et al. 2017). The success capacity of stakeholder engagement when configuring water exchange depends on several factors, such as power asymmetries in decision-making processes or political will to address oncoming challenges. However, advances in one context do not guarantee the same success in other situations (Guerrero et al. 2015). However, according to Eberhard et al. (2017), stakeholders tend to get involved in water exchange (1) to reduce existing tensions in favor of future water supply stability when drought or scarcity periods appear, (2) to provide an answer to water emergencies by agreeing on water strategies, plans, and measures to be applied in a consensual way and (3) to decentralize water responsibilities and increase the ability to react to climate risk. On the other hand, the promotion of wastewater reuse has been justified according to different associated benefits: (1) stability (as wastewater flows do not present wide variations seasonally and are independent from climatic conditions), (2) cost (in addition to being cheaper than other options, such as water transfers or desalination, savings on fertilizer costs are achieved), and (3) quality (wastewater treatments have been improved to achieve consistent and controlled quality standards). Furthermore, wastewater reuse contributes to environmental protection if it prevents the over-exploitation of surface or groundwater resources (Goonetilleke and Vithanage 2017) while guaranteeing ecological flows or landscaping (Nas et al. 2020). Additional benefits are related to the promotion of the circular economy (Neczaj and Grosser 2018) and nutrient recycling and fertigation through life cycle assessment (reducing the demand for conventional fossil-based fertilizers and, consequently, the consumption of water and energy) (Lam et al. 2020). However, although wastewater reuse can help meet the increased requirement for water across both the agricultural and domestic sectors, irrigation with reclaimed water carries both agronomic and environmental risks that require special consideration (Zhang and Shen 2017)—for example, microbial pathogens and micropollutants, as well as the higher salinity of the soil (Shakir et al. 2017). Furthermore, higher concentrations of plant growth-inhibiting ions such as sodium and chloride can lead to additional potential hazardous effects due to the increased sodium adsorption ratio (SAR), which may degrade soil's physical and chemical properties in the long term (Erel et al. 2019). Finally, other concerns, such as regulation and farmers' risk perception (yuck factor), have not been assessed or seriously considered, usually being disregarded (McClaran et al. 2020).

In some contexts, water exchange and wastewater reuse could be promoted as potential solutions to water scarcity in line with the Integrated Water Resources Management (IWRM) approach, closing the gap between water availability and water supply. However, the "integrated" approach requires overcoming technical issues and promote social learning by involving cross-sectoral collaboration, establishing agreements between confronted water users, and ensuring stakeholders' participation (Pires et al. 2017). Consequently, a water crisis could be considered a governance crisis due to the lack of collaborative management and unequal power relations between water users prevent reaching agreements to avoid water scarcity (OECD 2011). Substantial scientific evidence shows the importance of promoting mechanisms that ensure water management from collaborative governance, social learning, and stakeholders' agreements (Brisbois and Löe 2016; Ferguson et al. 2017; Ricart et al. 2019c). Participation and multi-stakeholder engagement are essential to achieve sustainable development (Benson et al. 2015), especially when addressing the potential of water exchange. However, identifying which factors are helpful for and measuring their effectiveness through indicators is still in its infancy (Guppy et al. 2019). Due to the lack of a universal solution neither a unique way to overcome these water challenges, this chapter address the research question "which are the key driving factors to enable water exchange?". In doing so, this work may be helpful to accomplish SDG 6 in other water scarcity regions by pointing out through social learning which water management components are facilitating or detrimental to the water exchange and wastewater reuse. Accordingly, this chapter goes deeper into the benefit of promoting water exchange and non-conventional water resources between agricultural and urban-tourism activities to close the gap between water supply and water demand while reducing water scarcity risk in the Marina Baja County in Alicante (Spain). This study case is an opportunity to translate some SDG6 theoretical objectives into concrete and innovative actions and improve the challenges and benefits of water cooperation among stakeholders.

2. The Marina Baja County and Benidorm City as Case Study

The Marina Baja County is located in the South-East of Spain (Alicante), on the Mediterranean coast. Its almost 580 km^2 area present sharp topographic and climatic differences, which cause that water resources are relatively abundant in the hinterland while the coastal area belongs to one of the driest regions in Spain. Likewise, there is relevant interannual variability of rainfall, so drought periods are frequent and, in some cases, may last for several years (Zaragozí et al. 2016). Furthermore, the land use activities vary significantly between the coast, dominated by tourism activities and inland irrigation development. In recent decades, the population of this county has strongly increased, currently standing at around 190,000 inhabitants, to which it must be added the seasonal population that can double or triple the resident population. Most of this socioeconomic growth has been generated around Benidorm, the most important mass tourism resort of Mediterranean Spain, attracting international and national visitors (Martínez-Ibarra 2015).

2.1. Water Supply System and Management

The recurrence of drought episodes in the Marina Baja County, together with an intense tourism development, has produced up to seven severe water crisis since the 1960s (1965–1969, 1978, 1981–1984, 1992–1996, 1999–2001, 2005–2008, and 2014–2016) (Hernández-Sánchez et al. 2017). The water crisis of 1978, which caused the shortage of Benidorm and required the arrival of tankers vessels to supply the city, was especially intense. A few years before, in 1976, the Marina Baja Water Consortium (from now on water consortium) was constituted by the most populated municipalities of the county, including Benidorm. The impact that the 1978 drought episode had on tourism, which had been turned into the main economic activity of the county, required the strengthening of the water supply system. Consequently, the water consortium relies on several water sources, including surface water, stored by two reservoirs, Guadalest (13 hm^3) and Amadorio (16 hm^3), from where the homonymous pipelines depart for urban-tourist water supply (Figure 1). Likewise, the water supply system includes groundwater resources from two karstic aquifers (mainly the Beniardá and the Algar pumping wells). During drought periods, groundwater pumping is increased, even inducing transient overexploitation, but its piezometric levels are recovered quickly since present a high recharge capacity during heavy rains. Additionally, it should be mention that the Algar-Guadalest and the Amadorio basins are interconnected through the Canal Bajo del Algar (a semi-open irrigation channel) and the 900 mm pipeline, that allow the mobilization of water to irrigation uses and municipal water tanks, and even the pumping water to the Amadorio reservoir through the Torres Pumping station. Finally, the water consortium manages the reclaimed water produced at the Benidorm wastewater treatment plant, conveying it through the reuse pipeline. This reclaimed water incorporates tertiary treatment (an ultrafiltration process) and a desalination stage to correct the conductivity levels required by the irrigators, fixed by the agreement established with the water consortium.

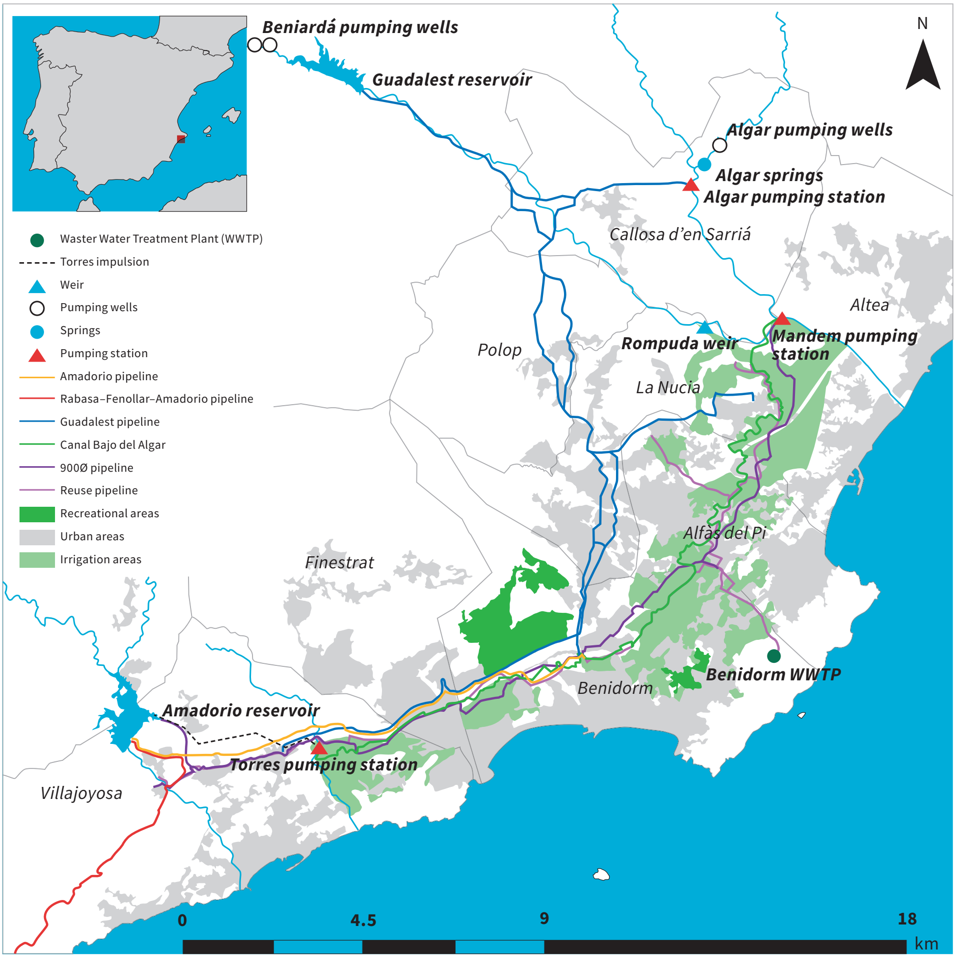

Figure 1. Water supply system and water demand areas of the Marina Baja Water Consortium municipalities and the Canal Bajo del Algar irrigation community. Source: Adapted from Ricart et al. (2019a).

2.2. Agricultural and Urban-Tourism Water Demands

The approval of the Benidorm urban Master Plan in 1956 motivated the promotion of tourist activity as a strategy for social and economic progress, for which more than 60% of the tourist activity in the Valencian Community was concentrated in the Marina Baja County. Most of this activity takes place in the city of Benidorm, which accounts for 70,000 inhabitants and a floating population of 150,000 inhabitants each year (Olcina et al. 2016; Baños et al. 2019). Benidorm attracts around 2 million visitors and 16 million overnight stays (Hernández et al. 2017), which places the city as the fourth most visited tourism destination in Spain after Barcelona, Madrid, and the Canary Islands. Benidorm's great urban-tourist activity consumes half of the urban water supplied by the water consortium, around 10 hm^3/year, located in this municipality. About two-thirds of this water consumption is for tourist, recreational and commercial activities (Yoon et al. 2018). However, the water consumption per capita in Benidorm is lower (200 l/person/day) than that produced in other residential-tourist municipalities due to the high-density urban model and the implementation of several water efficiency measures in the hotel sector, such as the introduction of Mediterranean gardens or the installation of water-saving devices in bathrooms, kitchens and outdoor uses (Rico et al. 2019).

The agricultural sector, which counts for more than 4000 ha of irrigated land, uses about half of the total water managed by the water consortium. It should be noted that the water sources supplied to irrigation vary widely from year to year according to the availability of freshwater sources. During drought episodes, the share of reclaimed water used for irrigation uses may reach 70%, as happened in 2000, but usually this figure oscillates between 8% and 38%. The main crops grown in Marina Baja County are medlars, citrus, and other fruits, coexisting with dryland crops such as carob, olive, and almond trees (Bellot et al. 2007). Irrigation modernization systems (such as drip irrigation) have been promoted, and nowadays, water efficiency systems are applied in about 80% of the plots.

2.3. Agreements between Key Stakeholders

The water supply system managed by the water consortium has been possible thanks to the agreements established with the irrigation communities consisting of the shared use of the main water infrastructures and the exchange of water resources (Gil and Rico 2018). In this regard, the agreements carried out with the Canal Bajo del Algar irrigation community are significant and can be traced back to 1964, even before the consortium's foundation. Until 1990, most of the agreements were verbal based on goodwill between stakeholders, but there were numerous agreements written at the beginning of the decade. One of them was signed to establish the permanent rules of water exchange: during drought or water scarcity situations, reclaimed water from the wastewater treatment plant of Benidorm will be supplied to the irrigation community in return for freshwater from the Algar-Guadalest watershed, whose water rights belongs to the irrigators. This agreement also establishes that the water consortium should assume the maintenance and operational cost of the water distribution system and an annual contribution of EUR 600,000 a year to the Canal Bajo del Algar irrigation community to guarantee up to an equivalent volume of 3 hm^3 of reclaimed water. Likewise, in 1991, a second agreement between the water consortium and the Canal Bajo del Algar irrigation community allows the joint use of the Canal Bajo del Algar for the water conveyance from the Algar-Guadalest river to the Amadorio reservoir.

3. Methods

Thematic analysis is a method to qualitatively analyze and evaluate non-empirical data, such as transcribed semi-structured interviews (Thomas et al. 2019). This method proposed by Braun and Clarke (2006) and later adapted by Zhu et al. (2019) allows the identification and characterization of common themes (topics). A theme is an abstract entity that brings meaning to a recurrent experience and its variant manifestations or patterns. It captures and unifies the nature or basis of the experience into a meaningful whole (Nelson et al. 2019). Applied in our case study, the main objectives of this analysis are (1) to identify the main factors that have enabled the water exchange between agricultural and urban-tourist users, and (2) to point out the potential social learning of this case study for the promotion of water exchange between agricultural and urban-tourist activities in other water scarcity regions.

Face-to-face semi-structured interviews were conducted in June 2018 with the two main stakeholders in Marina Baja County: the Marina Baja Water Consortium and the Canal Bajo del Algar irrigation community. Both interviews were undertaken in the city of Benidorm at the irrigation community's office. Each interview was conducted in Spanish and lasted 75 minutes in duration for the water consortium and 90 minutes for the irrigation community. Each stakeholder was previously informed about the research and contacted by email to fix the interview day. Both stakeholders collaborated voluntarily after providing their oral consent to participate in the study. An interview script was used following the standard tenets of thematic analysis and applying a deductive approach to identify those main driving factors of water exchange considered in the literature: (1) water management (Buurman and Padawangi 2018), (2) water quality standards (Ricart et al. 2019b), and (3) water charging (Cortignani et al. 2018). However, the sub-topics were not closed, and findings were presented to and discussed with interviewees to generate an integrative framework about the present and future water exchange in Benidorm. The audio of the interviews was recorded.

The recorded interviews were transcribed to identify the narrative of each interviewee according to the three themes previously defined in the literature. Inductive research has been applied when deepening each theme to identify the sub-themes considered by each stakeholder and avoid testing preconceived hypotheses (Figure 2). Significant quotations (the shortest part of a text where the primary meaning could be understood without reading a longer part of the text) (Walters 2016) have been hand-coded and grouped to each theme (driving factor), and sub-themes for each driving-factor have been highlighted and checked according to concord or discord among both stakeholders.

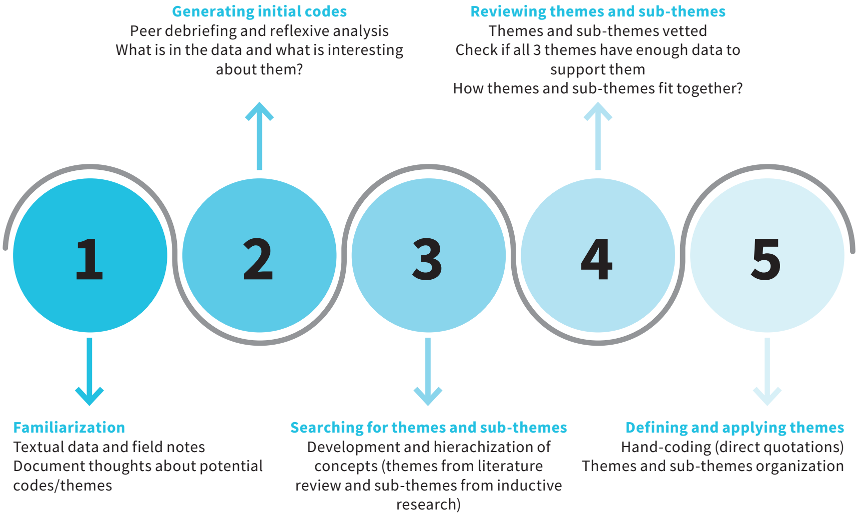

Figure 2. Thematic analysis process. Source: Figure by authors.

4. Results

This section analyzes the driving factors explaining water exchange motivations and discussion between the water consortium and the Canal Bajo del Algar irrigation community. The thematic analysis results, which are synthesized in Figure 3, are divided into three main driving factors (water management, water quality, and water charging) and the eight sub-themes were identified in the interviews considering benefits and barriers for the water exchange.

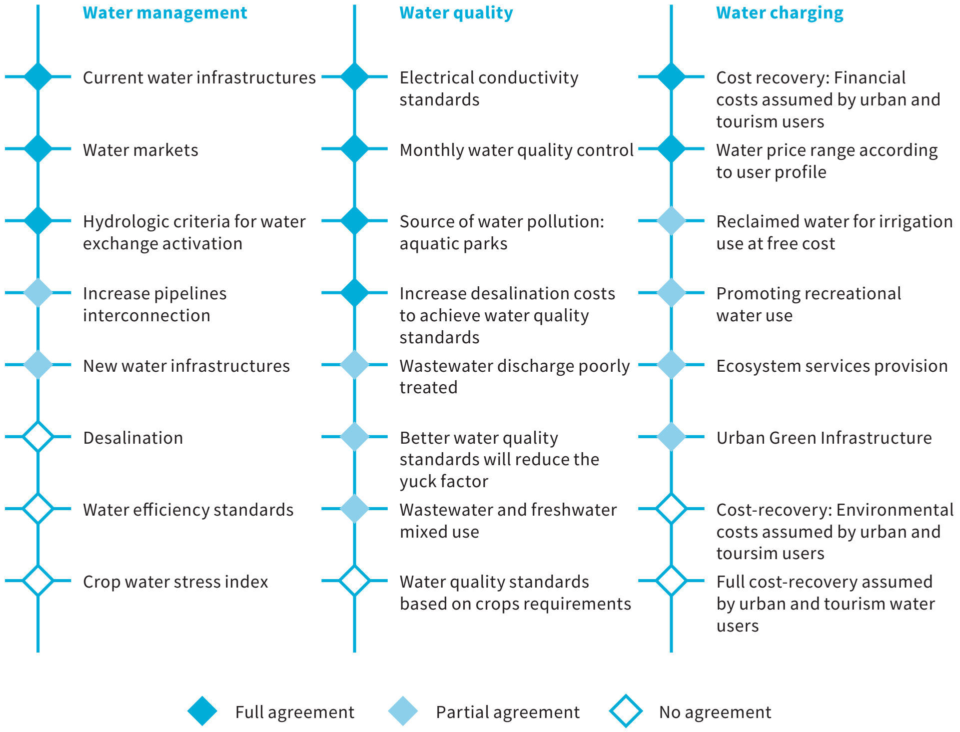

Figure 3. Major driving factors in water exchange identified by both the irrigation community and the water consortium. Source: Figure by authors.

4.1. *Water Management*

4.1.1. Infrastructures

For both the irrigation community and water consortium, the current hydraulic infrastructures used for the water exchange system are sufficient. However, each actor emphasized different issues related to hydraulic infrastructure. On one side, the water consortium stresses the importance of maintenance tasks to increase water efficiency standards, such as replacing pipelines or water interconnection improvements by converting one-way pipelines into two-way ones. Moreover, irrigators outlined the need to improve the management of the main infrastructures to enable the distribution of water resources among different water demands such as urban, recreational, or irrigation. Additionally, future infrastructure needs have been internally discussed by the water consortium to (1) increase the availability and ensure the management of conventional water resources, (2) promote alternative water resources (such as desalination), and (3) manage future water markets in which private companies could buy and sell water surplus through water exchange.

4.1.2. Water Exchange Protocol Activation

There is no activation protocol per se since water exchange is fixed by the water consortium depending on water availability and raining patterns. According to the water consortium, this means that, when assessing the need to activate or not the water exchange mechanism, irrigators must recognize a high level of trust in the criteria applied by the water consortium following technical recommendations. Although both the water consortium and the irrigators' community agree on the suitability of using water availability criteria to decide about the activation of the water exchange protocol, the irrigators' community considers that this criterion is not sufficient. Accordingly, it would be helpful to set a list of transversal criteria (not only hydrological but agronomic). For example, a crop water stress index would be considered to avoid adverse effects on crop production if there is a delay in the decision to activate the water exchange.

4.1.3. Water Concession

The water consortium has an available water concession of 28.8 hm^3, of which the irrigation community reaches 7 hm^3 of reclaimed water and 2 hm^3 of freshwater. The agreement established between the consortium and irrigators allows the irrigators to obtain about 3 hm^3 of reclaimed water—at no cost—from the Benidorm wastewater treatment plant to assign part of the surface water rights to the water consortium. If irrigators want to request additional reclaimed water, they must pay 50% of the total water cost while the water consortium assumes the rest. This example of solidarity from the irrigators' community is positively recognized by the water consortium, although considers that the tourism sector (tourists) does not perceive it.

4.2. Water Quality

4.2.1. Quality Standards

Electrical conductivity is the main parameter to define the appropriateness of using reclaimed water for irrigation according to the fixed quality standards between the Marina Baja Water Consortium and the Canal Bajo del Algar irrigation community. After the wastewater treatment in the Benidorm plant, the values should be lower than 1300 µS/cm. Notwithstanding, sometimes this level is exceeded according to irrigators, which may harm the soils and the crop productivity. This perception does not match the opinion of the water consortium, for whom water quality standards are completely acceptable, although, on some occasions, the extreme levels of salinity cannot be reduced as no specific mechanism of correction is available. The irrigators proposed reducing conductivity levels by mixing reclaimed water with freshwater from the Canal Bajo del Algar channel. Complementary solutions could include differentiating water quality standards according to crop demands—avocado, for example, is a sensitive crop that requires higher quality water standards, while citrus tolerates higher values, although its production is affected by high boron values. However, this option seems to be theoretical as it would require high investment in infrastructures that the irrigators' community cannot assume, while it is not included in the list of future investments to be carried out by the water consortium.

4.2.2. Sources of Water Contamination

The high level of wastewater salinity may be due to several sources: aquatic parks located in Benidorm; geothermal energy use by some hotels; and seawater intrusion into urban sewage networks. The first two activities are based on the extraction of water resources from the salinized coastal aquifer, so may be increasing wastewater salinity since this water is directly discharged into the sewage network without treatment. This process motivated an increase in costs associated with the desalination process and decreased reclaimed water production, which caused water supply delays. Likewise, irrigators pointed out a key factor to explain the high salinity values: the breakage of the brackish water collector executed some years ago in one of the aquatic parks to avoid discharges to the sewerage network. Although the water consortium did not indicate which potential sources of contamination would explain the increase in wastewater salinity, they expressed their concern about this problem. Additionally, the water consortium recommends hotels to end up with high conductivity wastewater discharges to the sewage network, as the Hotel Business Association of Benidorm, Costa Blanca, and Valencian Community (HOSBEC) recognized specific cases in the hotels that use geothermal energy.

4.2.3. Mechanisms of Control

Both the water consortium and the Public Entity of Wastewater Sanitation of the Valencian Community applied specific control mechanisms of reclaimed water quality standards. Furthermore, periodic analytics of electrical conductivity levels have been carried out on the wastewater treatment plant of Benidorm to detect outliers and identify potential sources of contamination. Irrigators, for their part, have also conducted monthly analytics to evaluate conductivity and general water quality standards. In their opinion, mechanisms of control are necessary to reduce the yuck factor expressed by some irrigators: scandals such as the low-quality standards of reclaimed water discharged to rivers or the cross-contamination between reclaimed water and urban water generate distrust on the water consortium role and in the water exchange process.

4.3. Water Charging

4.3.1. Polluter Pays Principle and Recovery Cost

The implementation of the cost recovery principle fixed by the European Water Framework Directive is not a key factor of the water exchange agreement. According to the irrigation community, the fulfilment of this principle, including environmental and resource costs, would mean that urban end-users should guarantee the optimal water quality conditions of returned freshwater into the system by assuming the extra cost of the tertiary treatment and the complementary desalination process conducted by the Benidorm WWTP. Although this possibility has been discussed among irrigators and the water consortium, an agreement was not achieved. For irrigators, only financial costs related to operational and maintenance tasks are currently being recovered by the urban and tourist sector, while the water consortium does not consider the environmental and resource costs.

4.3.2. Water Pricing: Costs and Incentives

The water exchange agreement enables the irrigation community to pay EUR 0.05 m^3 for up to 3 hm^3/year of reclaimed water generated by the water treatment plant of Benidorm, while recreational users assume EUR 0.35 m^3. This price range is established to ensure that the higher prices paid by both golf courses and public and private gardens compensate for the lower water price assumed by farmers. However, the difference between the recreational and irrigation use of reclaimed water is not enough to recover the actual cost of complete wastewater treatment (around EUR 0.42 m^3 considering secondary and tertiary treatment cost). The Consortium assumes the cost of the tertiary treatment for up to 3 hm^3/year, at about EUR 0.20 m^3, while after that volume, irrigators assume part of the cost. The secondary treatment is assumed by the public entity for wastewater sanitation (EPSAR) through the sanitation and purification fee. Future climate scenarios predict an increase in water price, particularly in drought periods affecting water scarcity regions, potentially jeopardizing the irrigators' ability to pay for reclaimed water and existing problems associated with high conductivity levels. Subsequently, the irrigation community has pointed out some strategies. The main one was to modify its foundational statutes to recognize the change in the use of their freshwater rights initially assumed for irrigation to recreational water uses in which non-potable water consumption of golf courses and tourist resorts' gardens could be included. In this way, the change in water use of some recreational users, who are part of the irrigation community, is regularized to avoid legal conflicts concerning the different rates for reclaimed water.

5. Discussion and Conclusions

Water scarcity is a growing environmental concern and a structural problem in many semi-arid regions, such as the South-East of Spain. Agriculture and urban-tourist water demands are two of the economic activities highly exposed to the effects of water scarcity, which also requires more significant attention to guarantee water security (Gunda et al. 2019). However, water security means much more than coping with water scarcity. It means managing water resources in a sustainable, efficient, and equitable way while delivering water services reliably and affordably to reinforce relationships between service providers and water users (Tundisi et al. 2015). This chapter aimed to more deeply explore ways to face water scarcity risk by promoting water exchange between agricultural and urban-tourism activities and wastewater reuse in Marina Baja County, in Alicante (Spain). The obtained results highlighted how facing water scarcity in semi-arid regions where conflicting water uses coexist can be governance-based rather than technology-based, as demonstrated by the agreements between the water consortium and the irrigation community. This new perspective is an example of desirable transition and transformation towards stakeholders' learning and knowledge integration when addressing sustainability. Both depend on perceptions, values and cognition and are often used to express the ambition to shift from analyzing and understanding problems towards identifying pathways and solutions for desirable environmental and non-linear societal change (Patterson et al. 2017; Hölscher et al. 2018). Increasingly, researchers recognize that water scarcity and water security require analysis from a multidisciplinary perspective that includes governance, social acceptance, and users' needs (Wuijts et al. 2018). Consequently, both pressures on water resources and water users' attitudes define water hotspots and complexities (Dargin et al. 2019).

Although water exchanges are often detrimental to rural interests due to decreased freshwater availability, in our case study, agricultural and urban-tourism activities are mutually dependent and contribute to the sustainability of the water management model. This mutual benefit is motivated by (1) seeking consensus through strengthening collaboration and comprehension between stakeholders and (2) recognizing the solidarity of the irrigation community when sharing their water rights (Ricart et al. 2019a). This case study has shown an experience that differs from the temporary water rights exchanges established in the Consolidated Text of the Spanish Water Law (Articles 67–72, Legislative Royal Decree, 1/2001), since this mechanism grants more flexibility in the water exchange management, which is carried out jointly among the stakeholders. According to the United Nations and World Economic Forum, water exchange could also be considered a mechanism to improve the "nexus approach" required when managing food-energy-water nexus by policy-makers and interdependent sectors and activities (Nie et al. 2019). In the analysis of the Marina Baja County, this nexus has been addressed by (1) focusing on the role and behavior of key stakeholders (SDG target 6b, Participation in water and sanitation management) and (2) sharing local knowledge, social-learning, and expertise in decision-making processes in which water management and good governance must be addressed (Bellamy et al. 2017). Furthermore, water exchange has been promoted and managed through informal agreements before drought periods occurred, as an example of pre-adaptation capacity based on interdependence, mutual commitments, shared responsibility, and reciprocal obligations among stakeholders (Fader et al. 2018).

Water infrastructure (including dams, reservoirs, and water transfer) is often built to cope with drought and water scarcity. These human alterations of water storage and fluxes are often beneficial in the short term, as they can increase water supply for additional urban or agricultural development (Zeff et al. 2016) or ensure economic growth (Fletcher et al. 2019). This supply–demand cycle is self-reinforcing feedback or a vicious cycle, as the occurrence of a new drought or water stress period could further expand water infrastructures. However, future urban-tourism developments in Benidorm and the associated increase in urban water demands jeopardize the current agreement between the water consortium and the irrigation community. The strategy followed by the irrigation community was to modify its foundational statutes to recognize the change of the use of their freshwater rights initially assumed for irrigation to recreational by some water users. This fact reveals a significant issue that claims attention: the number of farmers is declining due to the lack of generational renewal, and arable land decreases similarly. How will both factors affect water rights to guarantee the accomplishment of the conditions fixed in the agreement with the water consortium? This question adds up to significant short-term factors identified in the interviews between the water consortium and the irrigation community, such as effectively managing water infrastructure according to available investment or ensuring water quality standards by overcoming water pollution sources. The irrigation community and the water consortium perceive some questions differently, such as the lack of agronomic criteria to activate the water exchange, the occasional lack of minimum water quality standards, or how to achieve the polluter pays principle and the recovery cost. However, water exchange and wastewater reuse are considered mechanisms to ensure the viability of agricultural and urban-tourist activities by increasing water use efficiency and supply (SDG target 6.4). Furthermore, some learnings can be drawn from the experience in Benidorm when considering if water exchange can also contribute to addressing water scarcity from an integrative perspective (SDG target 6.5, Integrated Water Resources Management). For example, by discussing how water exchange and reclaimed water could be used to promote environmental externalities, such as urban ecosystem services or urban green infrastructure (UGI), especially when addressing compact city development in hydrosocial territories, such as Benidorm (van der Jagt et al. 2019).

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Transitioning to SDG 6: Climate Change Influence on Clean Water and Sanitation in Nepal

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1. Background

1.1. Climate Change and Global WASH

Climate change is among the critical challenges of the twenty-first century. An annual mean global temperature of 1.5 degrees centigrade (°C) above the pre-industrial global average is expected to be reached within a few decades; this is likely to impact natural and human systems (Intergovermental Panel on Climate Change IPCC). With the temperature increases, changes in the precipitation patterns and frequent occurrences of extreme events, such as floods and landslides, start to show (Baidya et al. 2008). These consequences pose a threat to various sectors with a potential significant impact on water, sanitation, and hygiene (WASH). Globally, the impact on water supply comprises damage to infrastructure, decreased water at the source, and change in water quality. Similarly, the impact on sanitation includes damage to sanitation infrastructures and loss of services from climate-induced disasters, such as floods and landslides (Howard et al. 2016). Available studies in different parts of the world have shown increases in microbial contamination with the increase in extreme events (weather) (Hynds et al. 2012; Kistemann et al. 2002; Jung et al. 2014). A study conducted in Norway concluded that climatic activities, such as heavy rainfall, are likely to increase fecal microorganisms and potential pathogens in water sources (Tryland et al. 2011).

1.2. Sustainable Development Goals—Emphasizing SDG 6 (SDG 6.1 and SDG 6.2)

With the realized need for sustainability and evident climate change, Sustainable Development Goals (SDGs) have been implemented, which also include sustainability goals concerning water and sanitation (SDG 6). SDG 6 focuses on the universal and equitable access to safe and affordable drinking water, sanitation, and hygiene (SDG 6.1 and SDG 6.2) (UN Water 2018). Other targets in SDG 6 aim to improve water quality (SDG 6.3), improve water-use efficiency (SDG 6.4), implement integrated water resources management (IWRM) (SDG 6.5), and restore water ecosystems (SDG 6.6) (UN Water 2018).

1.3. WASH and Climate Change in Developing Countries—Evidence from Nepal

The impact of climate change is realized on a global scale; its impact is prominent in developing countries as it aggravates the effect of increasing population, poverty, and rapid urbanization (Ludwig et al. 2007). The impact may be even worse among the poor and vulnerable populations of developing countries due to their low or lack of capacity to respond, or constraints in resources (McGuigan et al. 2002). It could be due to these constraints that water and sanitation are low priorities in developing countries. The low prioritized WASH is often accompanied by other constraints, such as lack of financial resources, lack of accountability, corruption, inefficient management, lack of enforcing water quality standards, and lack of proper monitoring guidelines (Howard and Bartram 2010).

Nepal, a developing country ranked fourth in the world in terms of climate change vulnerability (Maple Croft 2010), has a maximum temperature increase of 0.056 °C (Department of Hydrology and Meteorology DHM; Ahmad et al. 2019). Likewise, a 1.8 °C increase in annual average temperature was reported in Nepal between 1975 and 2006 (Dahal 2006; Karki 2004; Synnott 2012). This rate is higher than the global average. Nearly 80% of precipitation occurs in the form of summer monsoons from June to September (Department of Hydrology and Meteorology DHM). Rainfall trend analyses from 1971 to 2014 show that pre-monsoon rainfall in the High Himalayan areas has reduced by 0.74 mm per year (Department of Hydrology and Meteorology DHM). The changing monsoon pattern and the decreasing rainfall have also been widely evidenced in Nepal (Ahmad et al. 2019). The South Asian monsoon-dependent water sources of Nepal (Nepal Climate Vulnerability Study Team NCVTS) are consequently influenced by a range of effects, such as Glacier melt, snowmelt, rain-fed downstream spring, and groundwater recharge.

Though climate change impacts in various sectors are identified and noticed by the National Adaptation Plan of Action (NAPA) (Ministry of Environment MoE), the impact of climate on WASH is still a low-priority concern. This is apparent from the figures of the functionality and coverage of WASH. For instance, the national coverage for water supply of 87% (Budhathoki 2019) seems relatively progressive in terms of access; however, only 28.13% is functional (DWSSM 2019). Similarly, 97% of the population have access to sanitation, but this does not necessarily include improved sanitation facilities (Budhathoki 2019). The functionality and sustainability of WASH facilities and services are often disrupted by various climate change impacts.

In Nepal, which has completed the Millennium Development Goals (MDGs) and is transitioning towards Sustainable Development Goals (SDGs), climate change is expected to be a probable disruptive factor in attaining SDG 6 (National Planing Commisions NPC). This chapter highlights the evident climate change impacts in terms of WASH facilities and services in the context of the country's transition to SDGs.

2. Methodology

2.1. Search Criteria

The basis for this chapter was a review of both published articles and published and unpublished gray literature. We reviewed the published data on water, sanitation, hygiene, and climate change over the period of 1980 to 2020 covering global, national and regional scales. Electronic databases—Google scholar and HINARI—were searched using the keywords transition, drinking water, sanitation, hygiene, climate change, temperature, precipitation, and Nepal. The searches for the published data were confined to the literature with abstracts in English. The full text of the relevant studies was reviewed, and all citations were imported into an electronic database, Mendeley.

Published (hard copies) and unpublished documents, policy briefs, reports, power-point presentations, web content, and primary data from Government of Nepal (GoN) departments, such as the Department of Water Supply and Sewerage Management, Sector Efficiency Improvement Unit, Ministry of Water Supply, and the Department of Hydrology and Metrology were also considered for this study. Most of the gray literature was in Nepali language, with some in English; the literature relevant to the study objective was considered for review and, where possible, only the relevant section of the gray literature was translated.

2.2. Inclusion and Exclusion Criteria

Documents were included if: (1) the study was conducted in Nepal; (2) the sample size was more than 50 participants; (3) they were policy documents, sectoral reports, development reports, or web-based information from authorized GoN institutions; and (4) the study provided information on WASH and the climate change scenario of Nepal with SDG 6. We excluded studies that primarily focused on engineering aspects of WASH, and climate change-related studies that exclusively focused on climatological parameters (e.g., glaciology).

In this chapter, Nepal—a developing country—is presented as a case to signify the scenario of WASH in terms of climate change. Nepal is a South Asian country which is geographically and topographically diverse. With an annual maximum temperature increase of 0.056 °C (Department of Hydrology and Meteorology DHM; Ahmad et al. 2019), Nepal is among the most vulnerable countries in the world. Climate change impacts on various sectors of Nepal are often reported (Ministry of Environment MoE). Therefore, Nepal was among the most appropriate study areas that can provide significant evidence on climate change in terms of WASH.

3. Results

3.1. Transition from MDGs to SDGs

Millennium Development Goals (MDGs) (2001–2015) for water and sanitation aimed to halve the proportion of the world's population without access to safe drinking water and basic sanitation by the end of 2015. The MDG target for drinking water was met by the world, while that for sanitation was not (United Nations 2015). Currently, learning from the past, the world is heading towards Sustainable Development Goals (SDGs) that are often criticized to be ambitious (Sadoff et al. 2020). Attaining SDG 6 in terms of water and sanitation has various challenges and hurdles. UNDP has also identified climate change-related water stress and financial constraints in poor and developing countries as one of the challenges in reaching SDG 6 goals (UNDP 2020).

A comparative analysis of the target and progress of SDG 6, with the current pace and evident challenges, shows that it will be challenging to meet SDG 6 by 2030 (Table 1) in Nepal. Starting from 2015, it aimed to provide 35% of the population with safe drinking water, but it was only feasible to reach 25% of the population by 2019, which clearly shows that SDG 6, in terms of safe water supply, is lagging. A similar figure is seen with the percentage of households with access to improved sanitation. The progress target was missed in 2019; only 62% was achieved against the target of 69.3% in terms of improved sanitation. The overall achievement is to be obtained by the end of 2030; however, the gap between progress target and progress achievement forces us to rethink probable challenges.

Table 1. MDG and SDG targets vs. progress for water and sanitation in Nepal.

		MDG 7 c		SDG 6		
		Target 2015	Baseline 2015	Target 2019	Progress 2019	Target 2030
	Target 6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all					
1	Population using safe drinking water (%)		15	35	25	90
2	Household with access to piped water supply (%)		49.5	60.3	49.6	90
3	Basis water supply coverage (%)	73	87	90.2	88	99
	Target 6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all					
1	Households using improved sanitation facilities which are not shared (%)		60	69.3	62	95
2	The proportion of population using latrines (%)		67.6	75.7	85	98
3	Sanitation coverage (%)	80	82	86.5	99	99

Source: Data from (National Planning Commission 2020).

3.2. CC and WASH: Impact on Water

The world has faced climate change-related water-induced issues, either in the form of water scarcity or water-induced disasters (Abbaspour et al. 2012). The drying up of water sources due to temperature increases (Abbaspour et al. 2012); water-induced disasters, such as flood and landslides, due to alterations in precipitation patterns and intensities (Ávila et al. 2016); and water contamination due to climate-induced disasters (Kohlitz et al. 2020) are among the water-related climate change impacts.

Impacts of the changing climate on water availability and quality are profound in South Asian countries. In Nepal, increasing temperature due to climate change has caused glaciers to melt rapidly, causing more critical floods in the lowlands of the Terai, along with slow-onset disasters, such as heat and cold waves (Ministry of Environment MoE; International Centre for Integrated Mountain Development ICIMOD; Kaji et al. 2020). Each year, floods disrupt water supplies, sanitation facilities, and people's hygiene practices, exposing thousands of families to significant health risks in the Terai region. Furthermore, most water points, including boreholes and pumps, are either washed away or submerged due to floods in the affected districts, and water sources are contaminated (Suman Chapagain 2017).

While the low land is facing problems caused by climate-induced disasters, the mountains are facing the problem of reduced water flow in natural springs and sources (Poudel and Duex 2017; Adhikari et al. 2020). A study conducted in the mid-hill region of the mountains showed that 73.2% of the springs used as water sources now have a decreased flow and 12.2% have dried up over the past 10 or more years (Poudel and Duex 2017). With the decrease in water at the source, microbial contamination is increasing with increasing temperature. Evidence has shown a significant correlation between climate change and water-borne diarrheal diseases (Bhandari et al. 2020), which is the result of microbial contamination caused by reduced water quantity at the source.

3.3. CC and WASH: Impact on Sanitation System and Hygiene

Climate change has an impact on sanitation in two ways: (1) reduced functionality and increased environmental contamination due to climate-induced disasters, and (2) interruption in the operation and maintenance of sanitation facilities due to water scarcity caused by increasing temperature (Sherpa et al. 2014; Howard et al. 2016). A recent flood in the Gaur Municipality of Nepal in 2017 impacted sanitation significantly; an ODF campaign was also interrupted by the flood. The number of households (HHs) without toilets increased to 14.99% from 9.2% due to the damaged infrastructure and sanitation facilities (Suman Chapagain 2017).

In addition to the impact of climate change on sanitation facilities and services, it should be emphasized that sanitation is a source of Green House Gases (GHGs) emissions. On one hand, several efforts, such as the climate-resilient sanitation safety plan (CR-SSP) are currently being tested to reduce the impact of climate change on sanitation in the country. On the other hand, sanitation is causing greenhouse gas emissions, despite the rapid development and investment to achieve SDG 6 (Intergovermental Panel on Climate Change IPCC). The IPCC stated that greenhouse gas emissions from onsite sanitation remain largely unquantified and, therefore, we need to conduct a robust study on this so that the trade-off can be carried out more systematically (Bates et al. 2008; Bogner et al. 2007).

3.4. CC and WASH: Impact on Public Health

Climate change factors, such as rising temperature, fluctuating precipitation, and climate-induced natural disasters, are found to be the main causes of prevailing impacts, which ultimately lead to various public health issues (Figure 1). Water-borne, water-washed, and vector-borne diseases are major issues of public health. The rising temperature certainly makes a favorable environment for disease-causing vectors (Oxfam 2009). Disasters and natural calamities are not to be mistaken for population casualties, but the after effect of those calamities is always the bigger threat and challenge—where again the aforementioned diseases are the major killers.

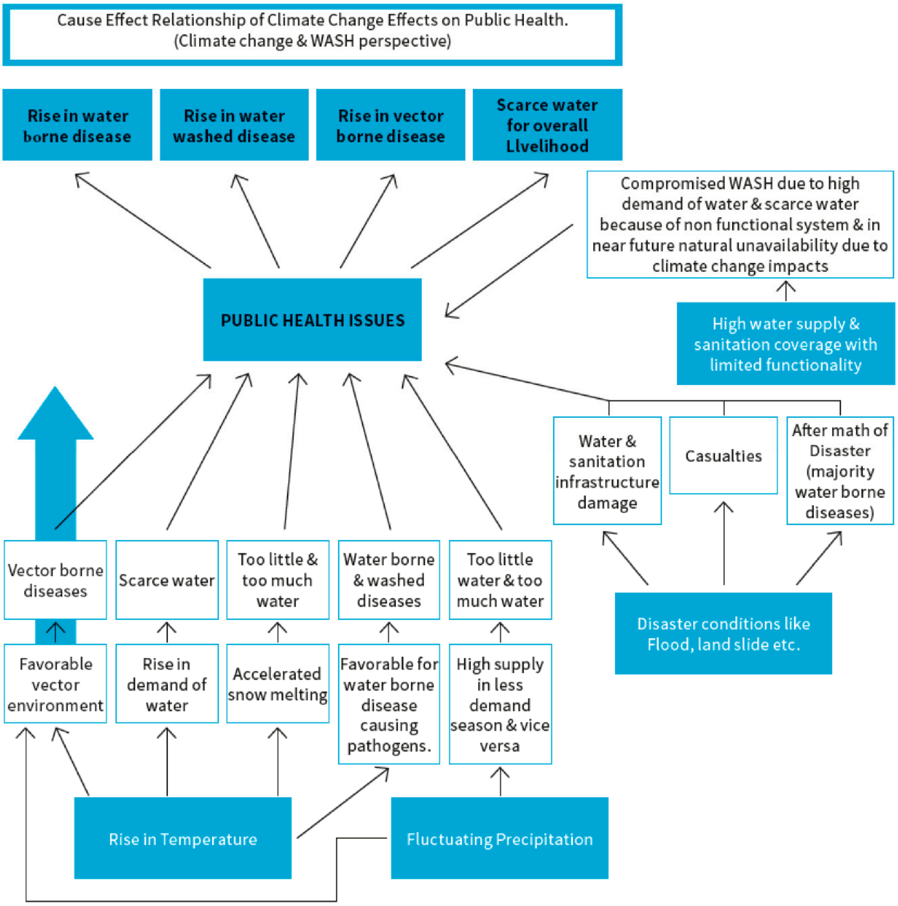

Figure 1. Cause and effect relationships of climate change effects on public health. Source: Figure by authors.

Along with casualties, such as life, properties, and livelihood, climate-induced disasters, such as floods and landslides, have a major impact on WASH infrastructures, such as water supply pipes, intakes, reservoirs, and sanitation facilities (Oxfam 2008; Ahmad et al. 2019). As a result, the functionality of the WASH infrastructures is ultimately reduced, leading to compromised public health (Figure 1). In addition to public health, there are various other sectors, such as agriculture, livelihood, and economy that will be severely affected by the impact of climate change on WASH. As it is specific to Nepal, the effect of this could be more devastating, as revealed in a study (Baral and Chhetri 2014); the study concluded that local and district level stakeholders have very a limited awareness of issues related to climate change. However, there is no doubt that the impact climate change on WASH will directly or indirectly impact overall sustainability goals.

3.5. Adaptation Practices to Reduce the Impact of CC on WASH and Public Health

Globally, the Paris Agreement at Conference of parties (COP) 21 in 2016 provides a strong legal provision to strengthen the adaptation to global climate change. The agreement brings all nations together for a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries in these efforts (Falkner 2016). The agreement provisions for financial, technical, and capacity-building support to the countries with a focus on developing countries to adapt to climate change (Garrett and Moarif 2018). Despite such provisions to the parties to UNFCC, in Nepal, WASH interventions have neglected climate change impacts and adaptation measures.

In Nepal, several efforts are required to adapt to the climate change impact on WASH. In countries such as Nepal, almost all WASH interventions have not considered climate and focused only on coverage; only in very few cases climate-resilient WASH is evident. A recent approach that seemed promising for reducing climate change's impact on WASH is the Water Safety Plan (WSP). WSPs are a comprehensive risk assessment and management approach, considered to be the effective means of consistently ensuring the safety of drinking water supply from catchment to consumer (World Health Organization WHO). An effective WSP will consider and prioritize all risks holistically as part of an overall system risk assessment (i.e., both climate- and non-climate related risks). It also locally addresses capacity building at the local level (Baidya et al. 2017). The Department of Water Supply and Sewerage Management (DWSSM) initiated the implementation of WSPs in all districts in 2008. Even after its implementation in almost 2000 water supply schemes, the sustainable implementation of WSP itself is affected by the factors such as the depletion of sources, increased disasters, and decreased water quality. Therefore, with the same principle as that of WSP, Climate Resilient WSP (CR-WSP) was initiated with considerations for climate change in 2018 (MWSS 2017) under DFID/WHO-supported projects on building adaptation to climate change in health in LDCs via resilient WASH. DWSSM developed a comprehensive training package on CR-WSP and developed corresponding CR-WSP implementation guidelines to support the process in both urban and rural settings (MWSS 2017). Though most of the steps in WSP and CR-WSP are the same, CR-WSP has incorporated climate change issues in every step of the plan. For instance, for the formation of the WSP team, a member should be a person with knowledge of climate change. CR-WSP also gives priority to the documentation, monitoring, and verification of specific impacts to the system by climate change (MWSS 2017). The Sanitation Safety Plan (SSP) is another approach that has recently completed its piloting activities in Nepal. The effectiveness of this plan to combat the climate change impact is yet to be examined. Apart from CR-WSP and SSP, other local-level adaptation strategies to adapt to prevailing water stresses are water harvesting (small scale structures), harvesting of rainwater, artificial groundwater recharge, conservation ponds, irrigation channels, and drip water irrigation (Kumar Jha 2011; Adhikari 2018). A potential study of rain harvesting in the Arghakhachi district of Nepal concluded that proper rainwater harvesting technology can compensate for immediate water uses, such as domestic use, irrigation, and even recharge groundwater, and contribute to springs (Water Supply & Sanitation Division Office WSSDO).

Though the existing local adaptation practices and indigenous practices are currently being implemented at the local level, evidence has shown that they are not hazard resilient (Karki et al. 2017) either due to resource choices or low economical capacity, which need to be prioritized to build a resilient WASH system.

4. Discussion

Despite several efforts by various countries, progress to date is not satisfactory in terms of SDG 6 (Sadoff et al. 2020). In 2018, a UN report reviewing progress towards SDG 6 found that the world is not on track (Ortigara et al. 2018). Transitioning from the MDGs' focus on water supply and sanitation to the much bigger framework of 'sustainable water and sanitation for all' of the SDGs poses numerous challenges. These challenges include geographical barriers, inequality, climate change, lack of interorganizational coordination, and proper monitoring approaches (Sadoff et al. 2020; National Planning Commission 2020).

In mountainous countries such as Nepal, the geographical barrier may hinder the commitment to the universal accessibility to water and sanitation for installing and managing WASH infrastructures (Sarwar and Mason 2017; National Planning Commission 2020). It will be difficult to extend water supplies to more hilly and mountainous regions in comparison to the Terai region of the country (Sarwar and Mason 2017). Providing equitable access to water and sanitation is among the aims of SDG 6.1, which is again challenging in Nepal. Identification of the vulnerable population is only based on data from the central bureau of statistics; the bureau, however, does not provide disaggregated data. Unless the upcoming census, i.e., 2021, is strengthened and more detailed, "reaching the unreached" for access to water and sanitation is impossible; it will deviate the country from SDG 6 achievements. With the existing geographical and equitable challenges, the lack of coordination among WASH sector actors could be another factor to delay SDG 6 progress. However, another factor relates to the lack of awareness of parallel initiatives in the WASH sectors (National Planning Commission 2020). The country has many overlapping concerned departments; NGOs/INGOs; and many local-level committees, such as the Water and Sanitation User Committee's (WSUC) working development of the WASH sector. It is a must that different actors, for instance, DWSSM, Department of Health Services (DoHS), and Department of Hydrology and Meteorology (DHM), coordinate and work together. This coordination can enable an integrated approach to meeting the sustainable water and sanitation goals.

Attaining ambitious SDGs can be critical as countries such as Nepal are in political transition: from the monarchy to federal democratic republic. Federalism may have created a dilemma in this transitional period where there is limited capacity and know how in the newly formed local system. The new system could have been an opportunity to address needs and new requirements, but the recent devastating earthquake, unstable politics, and now COVID-19 have seriously weakened the local government's status. Poor accessibility to water and sanitation facilities and hygiene practices, further compounded by the lack of proper protective gear for different frontline workers, has made Nepal a high-risk country in terms of the spread of the virus. In a country such as Nepal where 52% of people do not have hand washing facilities with soap and water at home, the COVID-19 crisis highlights WASH challenges, such as increased water demand for hand washing (Wateraid 2020).

Regarding all the problems and challenges, evidence from various findings and research have come to a common consensus that climate change will cause a disturbance in attaining SDG 6. Climate change has been recognized by Nepal in recent years; however, the government has very few plans and policies that actually consider climate change during the implementation of development activities.

Though the GoN has surpassed the MDG related to improved access to water and sanitation, huge disparities prevail among the regions, districts, villages, and communities reached. Only basic water supply and sanitation facility coverage increased, with no clear emphasis on the quality and resilience. Limited efforts have been made to address water quality issues. In a context where water supply and sanitation are poor, compromised drinking water quality poses multiple risks of morbidity. In such conditions, the synergetic effect of climate change immediately impacts WASH and public health with a range of effects, such as water- and vector-borne diseases, climate-induced disasters, the aftermath of disasters, and infrastructural damage. The emerging climate scenario is often linked to demands for climate-resilient infrastructures and interventions (Baidya et al. 2017). This overall scenario highlights the need and importance of climate-resilient WASH development.

5. Conclusions

SDG 6 appears ambitious, especially for developing countries such as Nepal where climate change is the biggest challenge; it can undermine the overall development goals of water and sanitation (SDG 6.1 and SDG 6.2). The timely realization and incorporation of climate-resilient WASH development with the proper coordination of different actors working on WASH can help to reduce the impact on WASH, and thereby make the transition to SDG 6 an achievement.

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6 CLEAN WATER AND SANITATION

Transitioning to Low-Carbon Drinking Water and Sanitation Services: An Assessment of Emission and Real Water Losses Efficiency of Water Utilities

Jayanath Ananda

1. Introduction

Environmental efficiency is considered as a foundational component of sustainable development (Matsumoto et al. 2020). Efforts to reduce greenhouse gas emissions (GHGs) to tackle climate change have put a spotlight on the environmental efficiency of water utility and sanitation services. They also urge these operations to transition into low-carbon operations. A substantial energy input is used in providing drinking water and sanitation services, particularly water supply augmentation, water and sewage treatment and pumping. In many countries, the traditional water supplies have been under pressure due to increased drought conditions and climate variability raising water security concerns. Climate-independent water supply options such as desalinisation have exacerbated energy use in recent times.

The drinking water and sanitation sector encompasses several Sustainable Development Goals (SDGs) of the United Nations. SDG #6 aims at achieving clean water and sanitation throughout the world; SDG #13 aims at implementing climate action and to reduce global greenhouse gas emissions. The water sector is also pivotal in ensuring SDG #12, sustainable consumption and production aiming at reducing the consumption of natural resources and pollution.

Environmental efficiency of drinking water and sanitation water services has received increased attention throughout the world in recent times (Ananda and Hampf 2015; Molinos-Senante et al. 2014; Molinos-Senante et al. 2018b; Ananda 2018, 2019; The Water Research Foundation 2019). This is unsurprising given the critical and multi-faceted roles that the sector plays in achieving sustainable development. In fact, the water–energy nexus has been a thriving area of publication in recent times, Pacetti et al. (2015), Chen and Chen (2016), Ackerman and Fisher (2013) and Head and Cammerman (2010).

The increased policy action to mitigate climate change and greenhouse emissions in recent times has forced the utilities sector to increase its environmental efficiency.

The GHG footprint of the water and sanitation sector is not insignificant. Globally, the water sector's GHG contribution is equivalent to 20% of the sum of committed reductions by all countries in the Paris Agreement (Ballard et al. 2018). In 2018, the electricity, gas, water and sanitation sector recorded 189.8 Mt CO_2-e and contributed 35.3% of Australia's total emissions (Commonwealth of Australia 2020). It should be noted, however, that the overwhelming majority of emissions in this figure come from the electricity and gas sector. Most reported water sector GHG emissions are energy-related, and they exclude emissions from non-energy related sources, often referred to as 'fugitive emissions' such as methane and nitrous oxide from wastewater treatment.

The drinking water utilities sector plays a critical role in sustaining communities and supporting economic growth. Figure 1 summarizes the global and local challenges faced by water utilities. It highlights the transformations that are occurring at three different levels: at the global level, national level and at the water utility level. At the global level, commitments made to international climate change agreements such as the Paris Agreement urge the signatory countries to reduce greenhouse gas emissions in an effort to limit the global temperature increase. For example, Australia is committed to reduce its 2000 emission levels by 5% by 2020 and 26% below 2005 levels by 2030 (Australian Government 2020). Several Australian states have a net zero emissions target by 2050. Moreover, increasing urbanization and population growth have put upward pressures on greenhouse gas emissions. At sectoral levels, various industries have come up with national plans to address greenhouse gas emissions and mitigate adverse climate change impacts. For example, the water industry peak body in Australia has developed a cost-effective and risk-based tool to assess carbon abatement for water utilities (Water Services Association of Australia 2012).

The majority of the sector's energy needs are met by fossil fuel electricity (Ananda 2018). The increased reliance on climate-independent water supply sources such as desalinization and recycled water has exacerbated the fossil fuel energy use and greenhouse gas emissions. The use of desalination water has increased significantly following the Millennium drought in Australia. Significant capital investment has been made on constructing desalination plants and enhancing water recycling capacity across the country in order to address water security concerns. All these new climate-independent capital assets are energy-intensive. Transforming the energy mix to renewables through innovative technologies and building resilience of water utilities to face adverse impacts of climate change while delivering 'value for money' for customers are the core challenges faced by water utilities. Transformation of the energy mix to renewable sources will enable to establish a sector low-carbon and sanitation services. This transformation should be aided by appropriate measurement frameworks to benchmark environmental efficiency.

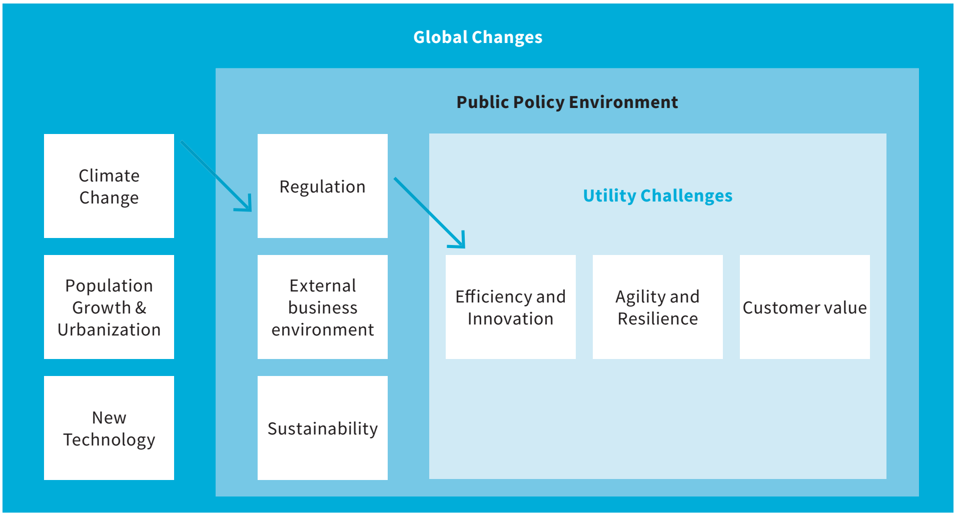

Figure 1. Framework used to respond to global and local challenges.

To formulate effective economic policies that align with sustainability, research that measures the relationship between emissions and economic growth is vital (Oh 2010b). Micro-level studies are needed to understand the links between the energy footprint and its economic and environmental performance. Some of the pertinent research questions include how to internalize undesirable outputs of production, what are the drivers of energy efficiency, how operational processes influence the energy footprint and thereby the economic performance, and what regulatory changes are required to promote sustainable development?

Utility regulation has traditionally been dominated by a neo-classical economic paradigm that seeks to control the natural monopoly power of utilities such as water, electricity and telecommunications. Often, conventional regulation is based on partial indicators or statistical benchmarking. However, the focus has been on desirable outputs and more recently quality aspects of outputs. In Europe, recently, there have been efforts to improve the knowledge base in urban water management from a resource efficiency perspective (European Environmental Agency 2014). Several recent studies focused on energy productivity and emissions (Ball et al. 2015; Hampf 2014; Dubrocard and Prombo 2012; Zhang et al. 2011; Choi et al. 2015). As regulated authorities, water utilities must select climate change responses that are cost-effective and environmentally efficient. By including bad outputs such as GHG emissions in the productivity analysis, policy makers could send a signal to water utilities to achieve emission reductions through energy efficiency, demand management, waste heat capture, energy capture and switching to renewables and other alternative energy sources (Water Services Association of Australia 2012). Such assessments will invariably facilitate the sector to transition into an environmentally efficient, low-carbon sector.

Although a large body of literature exists regarding the conventional productivity assessment in the drinking water and sanitation sector (Lannier and Porcher 2014; Molinos-Senante et al. 2018a; Molinos-Senante et al. 2017; Ananda 2013; Cunningham 2013; Sala-Garrido et al. 2019), studies that integrate environmentally undesirable outputs into productivity assessments are relatively scarce (Ananda and Hampf 2015; Molinos-Senante et al. 2014). It is noteworthy that efforts have been made in this regard in developing countries as well. For example, Kamarudin and Ismail (2016) incorporated non-revenue water as a bad output into the water utility performance in Malaysia. Kumar (2010) emphasized that the performance benchmarking of Indian water utilities must take into account service delivery aspects and non-revenue water. We extend the above strand of research by developing an environmentally sensitive productivity approach to benchmark water utilities. Our approach can accommodate multiple undesirable outputs of production. This study extends the work of Ananda and Hampf (2015) by applying environmentally adjusted productivity modelling framework to the Australian drinking water and sanitation services sector from 2013/14 to 2018/19. The specific objectives of this research are:

- To account for greenhouse emissions and real water losses in drinking water and sanitation services;
- To compute an environmentally sensitive productivity growth index;
- To analyze the drivers of productivity trends in the drinking water and sewage sector.

The remainder of this chapter is organized as follows. The next section outlines some theoretical underpinnings of the measurement of efficiency and productivity whilst accounting for undesirable outputs such as greenhouse emissions. It also discusses the data and the model specification used for the analysis. Section 3 discusses the main findings of the empirical analysis and the final section concludes the chapter.

2. Methods

Benchmarking productivity has been widely used in economic regulation of utility industries. A wide variety of water utility benchmarking approaches have been used in the literature, ranging from partial indicators of productivity to sophisticated statistical modeling approaches (Berg and Marques 2011; Torres and Paul 2006; Romano and Guerrini 2011; Cunningham 2013). They include total factor productivity, stochastic frontier analysis and data envelopment analysis (DEA). These methods are often used for quantitative assessments of the economic performance of industries, firms or countries. The nonparametric approach of DEA has several advantages over parametric methods, including the fact that it does not require a priori assumptions over the functional relationship that underpins the production process. This advantage comes at the cost of statistical noise that may be introduced into the analysis (Kneip et al. 2008; Simar and Wilson 2000).

DEA specifications take the form of a multi-factor productivity model that compares inputs and outputs of a production process. By using linear programming techniques, the approach constructs a non-parametric efficiency frontier comprising best-performing firms or benchmark firms. An individual firm's performance can be measured by comparing it to the efficiency frontier constructed.

Traditional measures of productivity growth such as Malmquist, Törnquist and Fischer indices focus only on the production of desirable outputs and do not consider undesirable outputs such as GHGs. The Malmquist index is based on ratios of distance functions and can be decomposed into efficiency change and technical change components. However, the production of desirable outputs, in this case drinking water and sanitation services, invariably involves environmental pollution, greenhouse gas emissions and water losses, which can be collectively termed undesirable outputs. Chung et al. (1997) highlighted that ignoring undesirable outputs of production from productivity measurement will lead to biased results undermining sustainability. In particular, the consideration of pollution externalities is important in benchmarking and regulatory decision making.

Chung et al. (1997) developed the Malmquist–Luenberger (ML) index that extends the conventional Malmquist productivity analysis to include undesirable outputs to produce a more meaningful measure of industrial performance (Shen et al. 2019). Based on the work by Pastor and Lovell (2005), Oh (2010a) developed the Global Malmquist–Luenberger (GML) index approach which circumvented the infeasibility problem of ML linear programming specifications. This study uses the GML index to estimate an environmentally adjusted productivity index. The global ML index can be decomposed into efficiency change and technical change.

The global ML index extends the analysis by measuring the shift in the frontiers between two periods (the technical change component) by comparing their relative position to the global frontier. This global frontier is the closure of the technology constructed by the total sample of all entities and their input–output combinations for all periods. This study applies the GML index using an input-oriented DEA. Appendix A provides the technical details of DEA, the global ML productivity index and its decompositions.

Data and Model Specification

Our data focus on a sample of integrated water and sanitation utilities in Australia. A dataset was collated for the period 2013–14 to 2018–19 from the National Performance Report 2018–19 (Bureau of Meteorology 2020). The dataset covered a total of 84 water utilities. It should be noted that utilities serving less than 10,000 customers are not part of the national reporting framework. We only selected the integrated water and sewerage utilities.[1] Utilities providing bulk water,[2] drinking water only and sewerage only were removed (9 utilities) from the original dataset. Fifteen utilities were removed from the sample due to missing data. The final sample comprised of 360 observations of 60 water and sanitation utilities over a 6-year period (2014–2019). The sample utilities come from all states of Australia except Tasmania. The sample water utilities included in the study provided both drinking water and sewerage services to a population of 21.5 million (approximately 86% of the total population) in 2018/19.

The model specification is a crucial step in production frontier studies. Therefore, our choice of input and output variables is driven by the literature and the empirical context. Many past studies on productivity performance have used operations and maintenance expenditure and capital expenditure as inputs for water sector productivity assessments and some studies have used the length of the water delivery network when reliable capital costs are not available (Worthington and Higgs 2014; Saal et al. 2007; Saal and Reid 2004; Ananda 2013). Accordingly, this study uses the operating cost (adjusted for inflation) and the length of water mains delivery network as a proxy for the capital stock as inputs in the DEA model formulation.

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[1] The terms 'water utilities' and 'water and sanitation utilities' are used interchangeably in this chapter. Most Australian water utilities provide an integrated service of potable for water drinking and sanitation purposes and collect wastewater from premises.

[2] Bulk water utilities are the wholesale water sellers that supply raw water to retail water utilities, and they do not directly deal with water and sanitation customers.

The operating cost of Australian water utilities include water resource access charges, purchase and transfer of raw water, salaries, wages and overheads of staff, and materials, chemicals and energy costs. The length of water mains included the network length that covers the transfer, distribution and reticulation mains.

The most widely used output measures of the water industry include the volume of drinking water supplied,[3] the volume of sewage collected and the number of connected properties (Ananda and Pawsey 2019; Saal et al. 2007). We chose the core outputs of the volume of drinking water delivered and the volume of sewage collected as good outputs and net greenhouse gas emissions and real water losses as bad outputs. The net greenhouse gas emissions variable measures the environmental footprint water and sanitation services and other activities. There is a tradeoff between emissions footprint and certain activities such as increased sewage treatment, which entails water quality benefits at the expense of increased emissions. The variable measures the direct (Scope 1) and indirect (Scope 2) emissions in tons of carbon dioxide equivalent. The values are adjusted for any carbon sequestration activities carried out by the water utility using the National Greenhouse Accounts (NGA) conversion factors. In addition to greenhouse gas emissions, we included real water losses as an undesirable output. Real water losses in the potable distribution system are due to leakage and overflows from mains, service reservoirs and service connections prior to customer meters (National Water Commission 2014).

Drinking water and sanitation providers have limited influence on the amounts of outputs produced because the government regulation mandates them to deliver potable water and sanitation services to the assigned population within a geographical area. Hence, we assume that a typical water utility minimizes inputs to a given set of good outputs and bad outputs. Accordingly, we specified the DEA linear programming model as an input minimization model.

3. Results

3.1. Descriptive Statistics and Emission Trends

Descriptive statistics of the input and output variables included in the analysis are presented in Table 1. Variables have been converted to per property values, which partially account for the sample heterogeneity in water and sanitation utilities.

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[3] The term ‘drinking water’ is used for brevity but it also includes water uses for sanitation.

The scatterplot matrices of input and output variables are shown in Figure 2. Pearson correlation coefficients are shown above the diagonal. Figure 2 indicates that there are no strong correlations among the frontier variables. There was a weak positive correlation between real water losses and the average residential water delivered. The same was true for greenhouse gas emissions and average residential water delivered.

Table 1. Descriptive statistics of variables.

Variable	Mean	S.D.	Max.	Min.
Bad Outputs				
Greenhouse emissions (tons/1000 properties)	396.1	205.1	1220.0	25.6
Real water losses (L/connection/day)	2.9	1.9	17.8	0.0
Good Outputs				
Residential water delivered (ML/property)	204.4	78.6	518.5	77.2
Wastewater collected (ML/property)	220.9	64.4	480.3	68.9
Inputs				
Length of water mains (km)	2798.6	4949.7	27,463.0	234.0
Combined operational cost ($/property)	979.5	292.3	3840.0	474.3

The temporal trends of the greenhouse gas emissions modelling are shown in Figure 3. Figure 3 shows that greenhouse emissions in the water sector vary with the utility size category. The National Performance Framework classifies water utilities into four categories based on the number of customers: Major = >100,000 customers (13 utilities); Large = 50,000–100,000 customers (10 utilities); Medium = 20,000–50,000 customers (17 utilities); and Small = 10,000–20,000 customers (20 utilities). The Major utility category recorded the lowest level of emissions per 1000 properties while the Medium utilities recorded the highest emissions levels. A range of factors affects GHGs of water utilities including the level of raw water treatment needed, the level of water demand, the degree to which the water utility relies on desalination and water recycling, the topography of the region, and the extent of the water pumping and wastewater network. Smaller utilities have higher energy use and emissions as they are typically located in regional and rural areas where water pumping must be carried out over large distances and the population is sparsely distributed. The GHG emissions of Major and Large utility categories have declined over recent times. The median GHG emissions have increased for all utility categories except the Medium category in 2018/19. One contributory factor could be the policies to reduce emissions culminating to the implementation of carbon tax in 2012. Although the carbon tax legislation in Australia was subsequently repealed in 2014, the GHG emissions of the water utilities appear to decline.

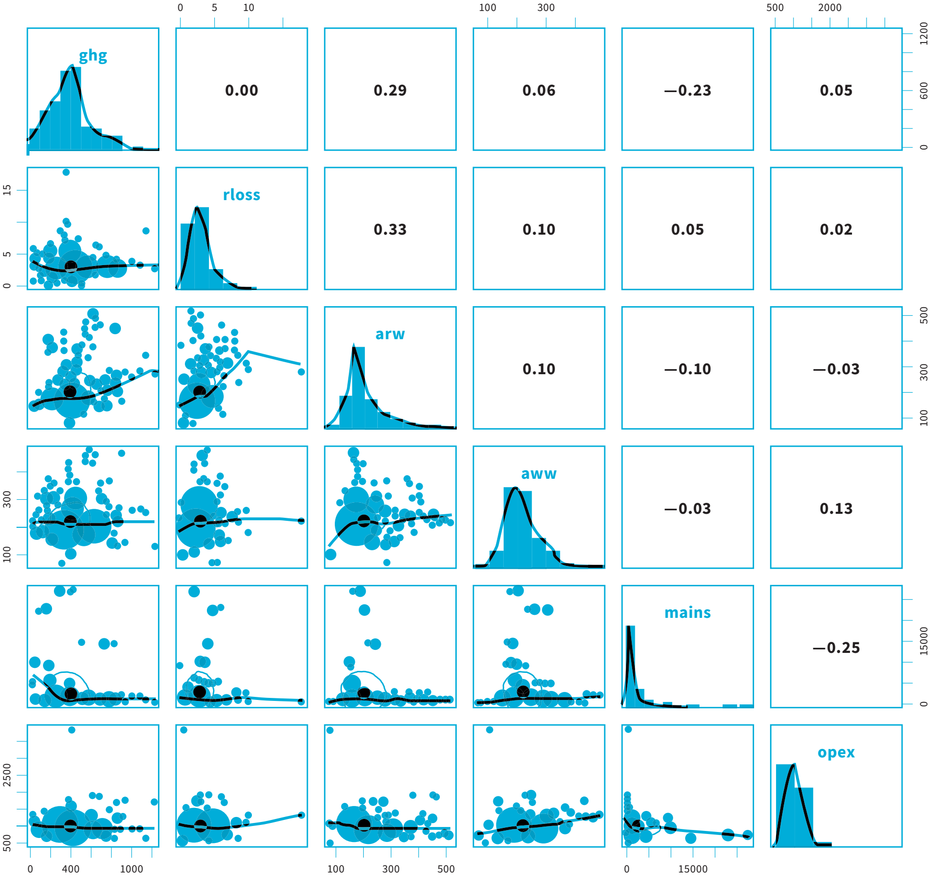

Figure 2. Scatterplot matrix of input and output variables. Key: ghg = Greenhouse gas emissions; rloss = Real water losses; arw = Average residential water supplied; aww = Average wastewater collected; mains = The length of water mains; opex = operational expenditure.

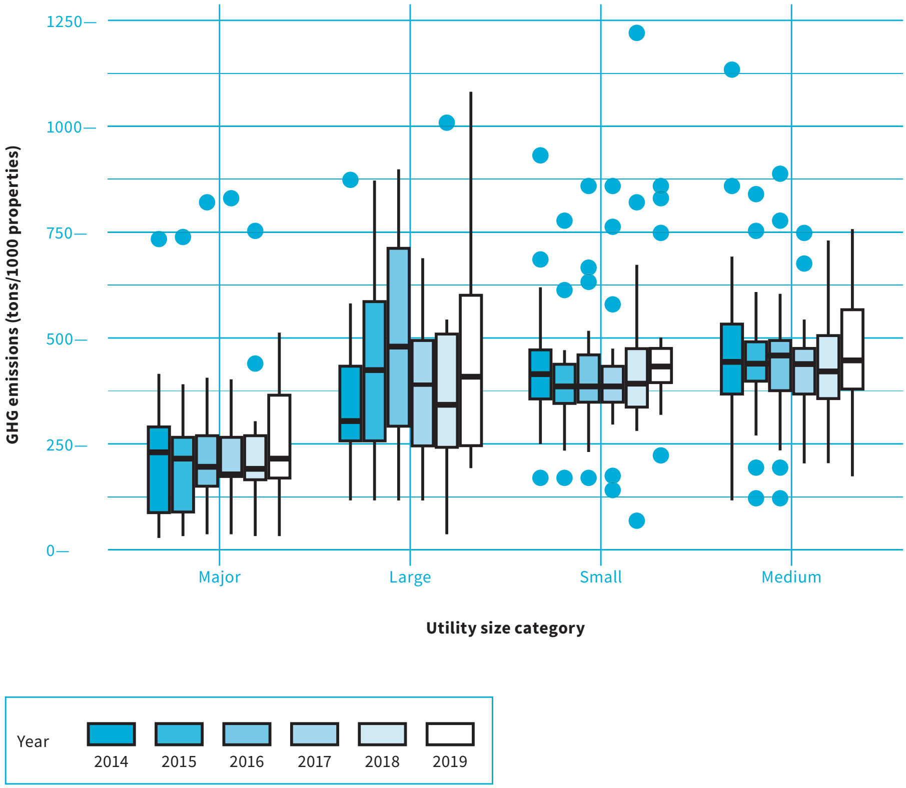

Figure 3. Boxplot of GHG emission trends by utility size category.

3.2. Productivity Trends without Undesirable Outputs

This section discusses the productivity trends. Table 2 presents the results of the conventional productivity analysis using the global Malmquist productivity index, which disregards the undesirable outputs (greenhouse gas emissions and water losses) in the estimation. Productivity change values greater (less) than one indicate an increase (decrease) in the productivity. Similarly, the values greater (less) than one in efficiency change (EC) and technical change (TC) indicate progress (regress) with regard to the components.

Table 2 summarises the mean cumulative productivity growth results. It indicates that conventional productivity of the water sector ranged from 3.4% (2018/19) to 7.7% (2016/17) during the study period. The productivity growth peaked during 2014/15 and 2016/17. A productivity growth of over 7% was recorded for both abovementioned periods. On average, the productivity has increased approximately by 5% per annum over the study period. However, since 2016/17, the productivity growth has somewhat declined.

Table 2. The conventional productivity, efficiency change and technical change from 2014/15 to 2018/19.

Year	PC [1]	EC [2]	TC [3]
2014/15	1.0741	1.0965	0.9797
2015/16	1.0394	1.0584	0.9828
2016/17	1.0772	1.0856	0.9930
2017/18	1.0478	1.0639	0.9859
2018/19	1.0340	1.0667	0.9703

[1] Productivity Change; [2] Efficiency Change; [3] Technical Change.

3.3. Productivity Trends with Undesirable Outputs

Table 3 and Figure 4 present the average environmentally adjusted cumulative productivity results using the global Malmquist–Luenberger productivity index. This productivity index accounted for greenhouse gas emissions and real water losses that occur in the production process. The environmentally adjusted productivity growth has occurred throughout the study period, but it is on a declining trajectory. The productivity growth ranged from 2% (2018/19) to 4.4% (2014/15) during the study period. Overall, the productivity has improved by 3% per annum on average. Over 4% productivity growth was recorded during 2014/15 and 2015/16. As shown in Figure 4, the efficiency change and productivity change growth followed a similar trajectory and efficiency change was largely responsible for the improved productivity outcome during the study period.

Figure 5 compares the conventional productivity growth as measured in the global Malmquist index and the environmentally adjusted productivity growth as measured in the global Malmquist–Luenberger index. In all time periods analyzed, except 2015/16, the conventional productivity growth outstripped the environmentally adjusted productivity growth during the study period.

Table 3. The environmentally adjusted productivity, efficiency change and technical change from 2014/15 to 2018/19.

Year	PC [1]	EC [2]	TC [3]
2014/15	1.0436	1.0387	1.0091
2015/16	1.0429	1.0732	0.9803
2016/17	1.0333	1.0536	0.9880
2017/18	1.0245	1.0296	1.0000
2018/19	1.0204	1.0393	0.9859

[1] Productivity Change; [2] Efficiency Change; [3] Technical Change.

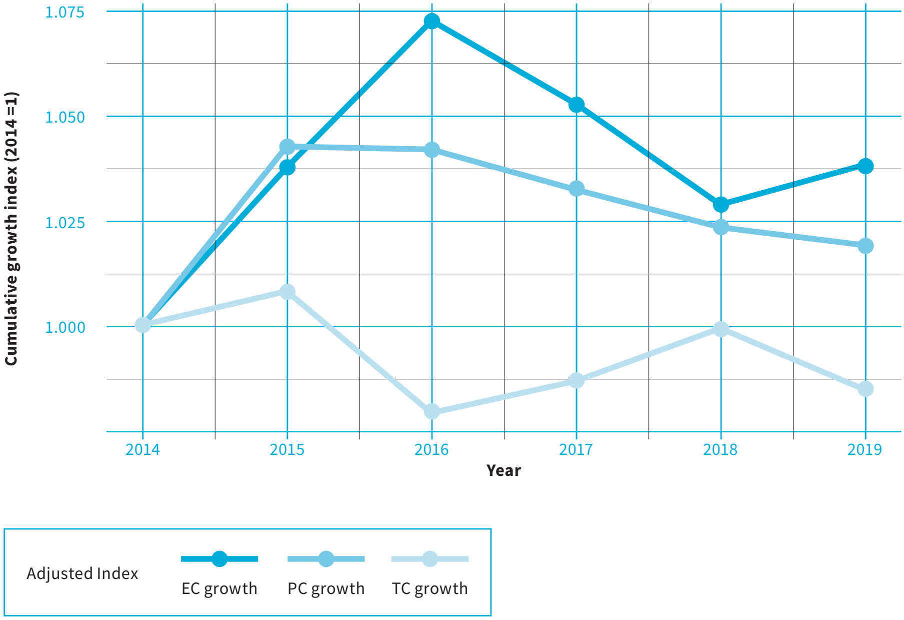

Figure 4. Environmentally adjusted cumulative productivity growth and its decompositions for the Australian drinking water sector, 2014 to 2019. Key: EC = Efficiency Change; PC = Productivity Change; TC = Technical Change.

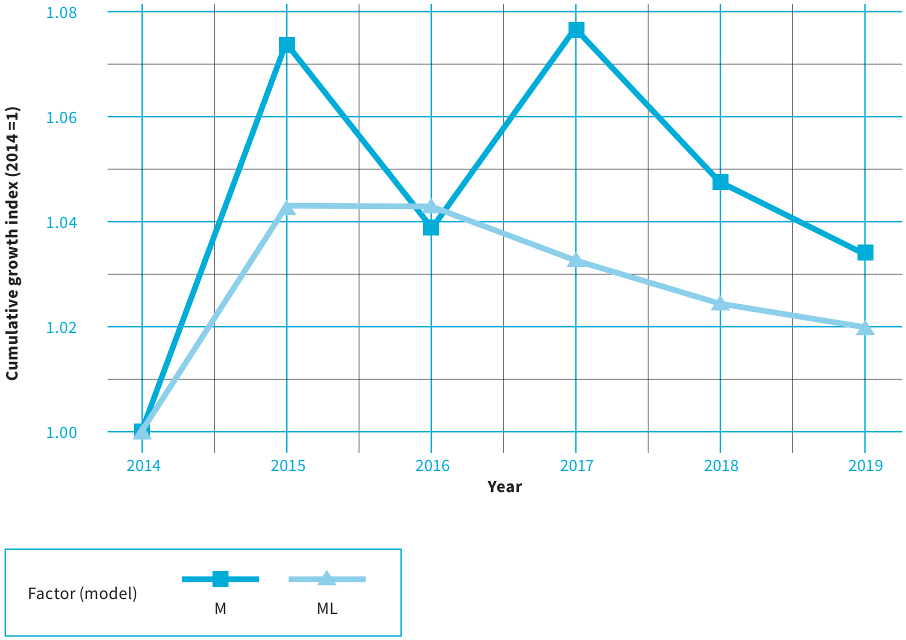

Figure 5. Comparison of environmentally adjusted cumulative (ML) and conventional (M) productivity trends for the Australian drinking water sector from 2014 to 2019. Key: M = Malmquist index; ML = Malmquist–Luenberger index.

3.4. Efficiency Change Trends

It would be useful to understand the underlying drivers of this productivity result. This can be explored by examining the decomposition of the productivity change index: the efficiency change and technical change. As can be seen from column 3 of Table 2, the traditional productivity improvement can be attributed to the efficiency change. The largest efficiency change growth (7%) occurred in 2015/16. The growth in efficiency change outstripped the technical regress facilitating an overall productivity growth.

Both conventional and environmentally adjusted efficiency change indices recorded growth during the study period. In fact, the productivity outcomes were largely, if not entirely, driven by the growth in the efficiency change. The conventional average annual growth of efficiency change ranged from 5.8% to 9.6% (Table 2). The environmentally adjusted efficiency change growth ranged from 3% to 7.3% over the study period. These results suggest that the average water utility experienced a 'catching up' effect moving closer to the contemporaneous technology frontier over the study period. In terms of environmentally adjusted index, water utilities recorded the highest catching up performance during the 2015–2017 period.

3.5. Technical Change Trends

Column 4 of Table 2 suggests that the technical regress occurred across all time periods except 2014/15 and 2017/18 under the conventional index framework. Approximately 2% annual average technical regression occurred during the study period. This indicates that the contemporaneous frontier has shifted inwardly. Interestingly, environmentally adjusted index framework yielded a slightly better technical change result with 0.91% technical progress in 2014/15 and neutral technical change (0%) in 2017/18 while showing technical regression the rest of the time (Table 3). The growth in efficiency change has clearly outstripped the growth in technical change. The growth trend of productivity change has followed a similar trajectory to that of efficiency change.

An increase in efficiency change coincides with the initial phase of the regulatory cycle (2014–2018) but this analysis cannot reason this as causation because many confounding factors are at play here. The technical regress during 2014/15 to 2017/18 means that water utilities did not adopt innovative technologies to minimize costs during this period. One plausible reason for this technical regression is that an increased technical regulation requirement preventing a best practice firm from using more inputs to produce a given set of outputs. These regulatory requirements include increased standards of security of water supply and environmental compliance requirements (Cunningham 2013). A 'knock-on' effect due to significant capital investments made in the aftermath of the Millennium drought in Australia to ensure water security may have also contributed to the technical regress. Such a level of capital investments cannot be sustained for a long time, but it appears that the sector's innovation efforts need lifting. It is also hard to pinpoint a single reason for the fluctuation of environmentally adjusted technical change without more in-depth research.

3.6. Productivity Trends by State and Utility Size Category

Variation in productivity and its decompositions were analyzed next. Utilities were classified into four size categories (see Section Data and Model Specification) and the trends were examined by state. Australia has eight states and territories and our dataset contained water utilities located in all states except Tasmania. Water and sanitation utilities in New South Wales were divided into two sub-categories, distinguishing between the metropolitan (NSW-m) and country or regional (NSW-c) water utilities. Figure 6 shows the environmentally adjusted productivity trends by state and utility category. It indicates that the productivity trends among states and utility categories are not homogenous. For example, Victorian Small water utilities recorded the largest environmentally sensitive productivity improvement over the study period while the productivity performance of NSW-country water utilities deteriorated somewhat.

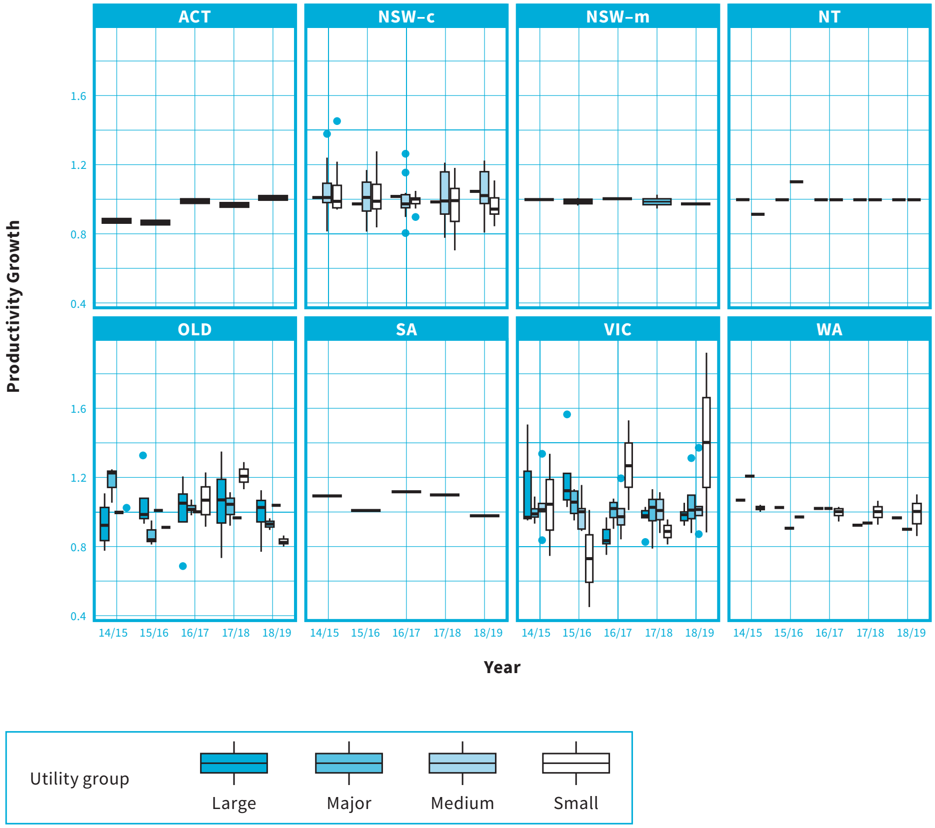

Figure 6. Environmentally sensitive productivity growth trends by state and utility group. Key: ACT = Australian Capital Territory; NSW-c = New South Wales—country; NSW-m = New South Wales—Metropolitan; NT = Northern Territory; QLD = Queensland; SA = South Australia; VIC = Victoria; WA = Western Australia.

The environmentally adjusted productivity trends in Australian Capital Territory (ACT), New South Wales metropolitan (NSW-m) and Northern Territory (NT) have been stagnant since 2016. The Victorian water utilities recorded the greatest variation in environmentally sensitive productivity results while NSW-m recorded the least variation in productivity over the study period. Water utilities in Queensland (QLD), South Australia (SA) and Western Australia (WA) showed a decline in environmentally sensitive productivity over the study period. In terms of utility size category analysis, Figure 6 shows that the performance of Major utilities in Queensland has deteriorated markedly since 2017/18.

4. Discussion and Conclusions

Undesirable and environmentally harmful outputs of production are often ignored by the traditional measures of productivity. It is worthwhile to note the discrepancy in the conventional productivity results and environmentally adjusted productivity results. Particularly, the conventional productivity analysis yielded a higher productivity growth compared to the environmentally adjusted productivity index. This result is consistent with the findings of similar studies (Oh 2010a; Ananda and Hampf 2015). The main implication of this result is that using conventional productivity frameworks will over-estimate the real productivity growth in the sector. The discrepancy in productivity results from the two approaches is not insignificant.

The overestimation of productivity is problematic for the sector for several reasons. First, the current productivity assessment totally ignores bad outputs such as GHG emissions, which contribute to climate change. In other words, water utilities with high emissions and causing environmental damage could be incorrectly deemed as ‘best performers’ or industry benchmarks. Second, from a policy evaluation perspective, the performance of water utilities that heavily rely on energy-intensive water supplies may differ from utilities that rely on environmentally friendly and less energy-intensive raw water sources. For example, water abstracted from a protected catchment or closed storage catchment is usually higher quality than water from open storage catchment and requires less treatment and therefore fewer emissions. Third, water utilities that have a lower environmental footprint may be penalized in traditional productivity evaluations. Fourth, by not accounting for real water losses and emissions therein, water utilities may appear ‘productive’ from an economic point of view at the cost of environment, which is detrimental to achieving SDG #12—sustainable production aiming at reducing pollution.

Within the framework of the global Malmquist–Luenberger DEA, this chapter presented an approach to measure dynamic changes in environmentally adjusted productivity of drinking water and sanitation services in Australia. The results indicated that in the sample period evaluated, the water and sanitation sector had an annual average growth rate of 3%. This productivity growth came from the growth in efficiency change. The analysis also revealed a declining 'green' (environmentally adjusted) productivity growth trajectory. Several factors such as increasing energy costs in recent times may have contributed to this decline in productivity. Steps must be taken to explore reasons for this trend and to minimize greenhouse gas emissions and real water losses using least cost strategies.

One limitation of the present study is that it assumed that the institutional environments in which the water utilities operate are homogenous. Additionally, the influence of extreme values on the production frontier is ignored. Future research should focus on addressing these two limitations. Particularly, accounting for group heterogeneities manifested by the geographical distribution of water utilities and varied jurisdictional policy frameworks are important in developing robust productivity assessments for sustainable development. Another improvement to the present study is to compute bias-corrected productivity estimates using bootstrap methods proposed by Simar and Wilson (1998). Uncorrected efficiency estimates tend to be slightly upwardly biased, although the overall distribution of estimates remains the same.

The approach presented in this chapter integrated the ideals of sustainability into the drinking water and sanitation services delivery by including greenhouse gas emissions and real water losses. Being a crucial sector, which deals with several SDG arenas, it is important to develop and test assessment frameworks that foster SDG targets. Without robust sustainability measurement frameworks, it is difficult not only to track the sectoral progress but also to transform water production and sanitation service delivery systems into more sustainable ones. Embedding innovative assessment frameworks such as the one presented in this chapter with regulatory frameworks will expedite the transition to low carbon drinking water and sanitation provision while advancing the SDGs.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

With input-oriented DEA, the linear programming model is configured in a manner that maximizes the technical efficiency of the *i*-th decision-making unit (DMU), in order to achieve a given output level. Following the notation of Coelli et al. (1998), this can be solved as an input minimization problem using the following LP programme.

$$\begin{aligned} &\min_{\theta,\lambda}\theta, \\ &s.t. \\ -\boldsymbol{y}_i+\boldsymbol{Y}\lambda &\geq 0, \\ \theta\boldsymbol{x}_i - \boldsymbol{X}\lambda &\geq 0, \\ \lambda &\geq 0, \end{aligned} \tag{A1}$$

where $\boldsymbol{y}_i$ is an $M \times 1$ vector of outputs produced by the i-th DMU, $\boldsymbol{x}_i$ a $K \times 1$ vector of inputs used by the i-th DMU, $\boldsymbol{Y}$ is the $M \times N$ matrix of outputs of N DMUs in the sample, $\boldsymbol{X}$ is the $K \times N$ matrix of inputs of the N DMUs, λ is an $N \times 1$ vector of weights and θ is a scalar measure of technical efficiency which takes a value between 0 and 1 inclusive.

The above formulation is known as the constant returns to scale (CRS) DEA formulation and it can be modified to allow the Variable Returns to Scale (VRS) DEA technology by adding a convexity constraint to the original minimization problem, resulting in the following linear program:

$$\begin{aligned} &\min_{\theta,\lambda}\theta, \\ &s.t. \\ -\boldsymbol{y}_i+\boldsymbol{Y}\lambda &\geq 0, \\ \theta\boldsymbol{x}_i - \boldsymbol{X}\lambda &\geq 0, \\ \boldsymbol{N1}'\lambda &= 1, \\ \lambda &\geq 0, \end{aligned} \tag{A2}$$

where $\boldsymbol{N1}$ is a vector of ones. The VRS formulation of DEA produces 'pure' technical efficiency devoid of scale effects and efficiency scores are either greater than or equal to those from the CRS problem. A scale efficiency measure for each DMU can be obtained by conducting both a CRS and a VRS DEA and then decomposing the DEA scores obtained from the CRS DEA into two components: one due to scale inefficiency and the other due to 'pure' technical inefficiency. The analysis assumed CRS technology following Färe and Grosskopf (2003). It should be also noted that the Australian water and sanitation sector is a mature industry and the above assumption is not unreasonable.

Calculating the Malmquist Productivity Index

Following the framework set down by Caves et al. (1982), the input-oriented Malmquist productivity change index is:

$$M_i^{t+1}\left(y_{i,t},\ x_{i,t},\ yi,\ _{t+1},\ x_{i,t+1}\right) = \left[\frac{D_I^t\left(y_{i,t+1},\ x_{i,t+1}\right)}{D_i^t\left(y_{i,t},\ x_{i,t}\right)} \times \frac{D_i^{t+1}\left(y_{i,t+1},\ x_{i,t+1}\right)}{D_i^{t+1}\left(y_{i,t}, x_{i,t}\right)}\right]^{1/2} \tag{A3}$$

where subscript i denotes the DMU (urban water authority in this case), M is the productivity of the most recent production point $\left(x_{i,t+1}, y_{i,t+1}\right)$ (for DMU i, using period $t + 1$ technology) relative to the earlier production point $\left(x_{i,t}, y_{i,t}\right)$ (for DMU i, using period t technology), y refers to outputs and x refers to inputs. Input distance functions are denoted as D. With regard to input-orientation, productivity values greater (less) than one indicate positive (negative) TFP growth from period t to period $t + 1$. In order to delineate the sources of TFP growth, Equation (A3) can be re-written as follows:

$$\begin{aligned} & M_i^{t+1}\left(y_{i,t},\ x_{i,t},\ y_{i,t+1},\ x_{i,t+1}\right) \\ & = \frac{D_i^{t+1}\left(y_{i,\ t+1}, x_{i,t+1}\right)}{D_i^t\left(y_{i,t}, x_{i,t}\right)}\left[\frac{D_i^t\left(y_{i,t+1},\ x_{i,t+1}\right)}{D_i^{t+1}\left(y_{i,t+1,}\ x_{i,t+1}\right)} \times \frac{D_i^t\left(y_{i,t},\ x_{i,t}\right)}{D_i^{t+1}\left(y_{i,t}, x_{i,t}\right)}\right]^{1/2} \\ & = EC_i^{t,t+1} TC_i^{t,t+1} \end{aligned} \tag{A4}$$

where M, the Malmquist total factor productivity, is the product of technical efficiency change ($EC^{t,\ t+1}$) and technological change ($TC^{t,\ t+1}$). The global ML index can be decomposed as

$$\mathrm{GML}^{t,\ t+1} = \underbrace{\frac{\theta^{t+1}\left(\boldsymbol{x}_{t+1}, \boldsymbol{y}_{t+1}, \boldsymbol{u}_{t+1}\right)}{\theta^t\left(\boldsymbol{x}_t, \boldsymbol{y}_t, \boldsymbol{u}_t\right)}}_{\text{MLEff}^{t,\ t+1}} \cdot \underbrace{\sqrt{\frac{\theta^t\left(\boldsymbol{x}_t, \boldsymbol{y}_t, \boldsymbol{u}_t\right)}{\theta^G\left(\boldsymbol{x}_t, \boldsymbol{y}_t, \boldsymbol{u}_t\right)} \cdot \frac{\theta^G\left(\boldsymbol{x}_{t+1}, \boldsymbol{y}_{t+1}, \boldsymbol{u}_{t+1}\right)}{\theta^{t+1}\left(\boldsymbol{x}_{t+1}, \boldsymbol{y}_{t+1}, \boldsymbol{u}_{t+1}\right)}}}_{\text{GMLTech}^{t,\ t+1}} \tag{A5}$$

where the superscript "*G*" denotes the global frontier. Again, the global Malmquist index can be obtained by removing the constraint on the bad outputs when calculating the distance functions.

Several scholars have proposed to modify the conventional productivity indices such as the Malmquist index to account for bad outputs (Yörük and Zaim 2005; Färe et al. 2012; Oh and Lee 2010; Zhang et al. 2011; Zhou et al. 2010). The seminal work of Chung et al. (1997) stands out in accommodating undesirable outputs in the productivity measurement. They modified the conventional Malmquist index by Caves et al. (1982) and developed the Malmquist–Luenberger index, which can explicitly take bad outputs into account. One limitation of the Malmquist–Luenberger index is the possible infeasible solutions when undesirable outputs are included in the estimation (Färe et al. 2001).

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6 CLEAN WATER AND SANITATION

The Challenge of Enforcing the Right to Water: The Case of the Vedanta PLC Mining Conglomerate in Zambia

O'Brien Kaaba

1. Introduction

Water is essential to the sustainability of human life. It is for this reason that it has been recognised as a human right. This right is widely recognised in international human rights law. However, it is still far away from being a daily reality for many people, especially in developing countries. This chapter presents a case analysis of how the right to water is hampered by Vedanta, a mining conglomerate operating in Zambia (until 2019) as a result of polluting and contaminating water sources the people depend on. It illustrates the real challenges of accessing justice in order to vindicate their right to water. Apart from this introduction and the conclusion, the chapter is divided into two distinct sections. The first section grounds the discussion by framing an understanding of the right to water in international human rights law by giving an overview of the right to water. The overview is premised on international human rights law, particularly the human rights treaty framework of the United Nations and the human rights framework of the African region. The second part discusses the substance of the chapter and demonstrates the three inter-related cases of victims of Vedanta's subsidiary in Zambia who organised themselves and sought justice from the Zambian Courts. Unable to obtain justice locally, they sought justice in the United Kingdom. This chapter is, therefore, an illustrative case commentary.

2. The Right to Water: An Overview

Water is increasingly being recognised as a human right. Its existence as a human right is now well established in the international human rights framework, both at the United Nations human rights treaty system level as well as the African regional level. It is provided both directly, or expressly, and indirectly, or implicitly, in many human rights treaties. A useful starting point is establishing the existence of the right to water in universal human rights treaties under the United Nations. Several UN human rights treaties expressly provide for the right to water. The conventions that directly provide for the right to water include the Convention on the Rights of the Child

(Article 24(2)(c)),[1] Convention on the Elimination of All Forms of Discrimination Against Women (Article 14(2)(h)),[2] and the Convention on the Rights of Persons with Disabilities (Article 28(2)(a)).[3] As already noted, the right to water may be provided for indirectly or implicitly. As an implicit right, the right to water is provided for in the Covenant on Economic, Social, and Cultural Rights (CESCR) (Articles 11 and 12) and the Covenant on Civil and Political Rights (Article 6). Several examples speak to this fact. Article 11 of the CESCR, for example, provides for the right to an adequate standard of living, while Article 12 provides for the right to the enjoyment of the highest attainable standard of physical and mental health. It is argued that the right to water is connected to these other rights because human life cannot be sustained without water. Without clean and adequate water, the rights to the highest standard of physical or mental health and an adequate standard of living would be futile. It is for this reason that the right to water is, therefore, recognised as a human right 'that is essential for the full enjoyment of life and all human rights' (UN General Assembly Resolution 64/292, 2010, para 1).[4]

The United Nations General Assembly in July 2010, adopted a resolution expressly recognising the right to water and declared 'the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights' (ibid.). The UN General Assembly Resolution was followed in September 2010 by the Human Rights Council resolution affirming the right to water. The Human Rights Council resolution associated the right to water with the rights to an adequate standard of living and highest standard of physical and mental health, life, and dignity, stating that it 'affirms that the human right to safe drinking water and sanitation is derived from the right to an adequate standard of living and inextricably related to the right to the highest attainable standard of physical and mental health, as well as the right to life and human dignity' (Human

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[1] Convention on the Rights of the Child, 1989. Available online: https://www.ohchr.org/EN/professionalinterest/pages/crc.aspx (accessed on 19 September 2021).

[2] Convention on the Elimination of All forms of Discrimination against Women. Available online: https://www.un.org/womenwatch/daw/cedaw/ (accessed on 19 September 2021).

[3] Convention on the Rights of Persons with Disabilities 2006. Available online: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html (accessed on 19 September 2021).

[4] UN General Assembly Resolution 64/292, 2010. Available online: https://undocs.org/pdf?symbol=en/a/res/64/292 (accessed on 19 September 2021).

Rights Council Resolution of 24 September 2010 (A/HRC/15/L.14, para 3).[5] The Human Rights Council called upon states to, inter alia, adopt mechanisms to achieve the progressive realisation of the right to access safe drinking and sanitation water, ensure transparency in planning and implementation processes for safe drinking water, meaningful participation of the people concerned, develop and impellent effective regulatory frameworks for service providers, and to provide effective remedies for victims (ibid.).

According to Lee and Best (2017), water should be 'adequate' for human dignity and, therefore, should not be simply treated as an economic good. This entails that in order to ensure that there is adequate water for human dignity in terms of quality, quantity, and access, the state must put in place active and effective measures. This necessarily means that the right to water, in terms of quality and quantity, is necessarily and ultimately connected to safe drinking water and sanitation, which are, in turn, ultimately linked to the right to life and health for the people (ibid.).

The General Comment on the right to water, that is, General Comment No. 15, conceptualises the right to water as entitling everyone to 'sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use' (Committee on Economic, Social and Cultural Rights, General Comment 15: The Right to Water (29th Session, 2003) UN Doc. E/C.12/2002/11 (2002), para 2).[6] The import of the definition is that although water may have several uses, which include use in industry and growth of crops, the right to water should give first preference or priority to the provision of water for personal and domestic use. The reason for this is self-evident. An adequate or sufficient amount of water is an absolute necessity for reducing water-related diseases, prevent dehydration and death, and invariably for drinking or consumption, domestic cleaning and hygiene, and cooking food for human consumption (ibid.).

In order for the right to water to be meaningful, water must be supplied in adequate quantities. Adequacy in this context entails, according to General Comment 15, three strands. These are that the water must be available (availability), it must be of appropriate quality for human consumption (quality), and it must be within easy reach (accessibility) (ibid., para 12). By availability, it is meant that the supply of water

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[5] Human Rights Council Resolution of 24 September 2010 (A/HRC/15/L.14. Available online: https://www.ohchr.org/EN/HRBodies/HRC/RegularSessions/Session15/Pages/ResDecStat.aspx (accessed on 19 September 2021).

[6] Committee on Economic, Social and Cultural Rights, General Comment 15: The Right to Water. Available online: https://www.refworld.org/pdfid/4538838d11.pdf (accessed on 19 September 2021).

to every concerned person should be sufficient and continuous or uninterrupted for personal and domestic use (which includes drinking, personal sanitation, washing of clothes, food preparation, as well as personal and household hygiene) (ibid., para 12(a)). Water is also required to be of appropriate quality. The reference to the quality of water entails that the water must be safe for human use and consumption; that is, it must be free of micro-organisms, chemical substances, and radiological hazards that may pose a danger to human health (ibid., para 12(b)). The third and final strand is that of accessibility. Accessibility to water means that the services and facilities providing water must be accessible without discrimination. Accessibility includes the physical reach of the facilities and services, affordability or economic reach of the water, provision of water without discrimination (especially for the vulnerable and poor people), and supplying water with appropriate and accessible information about the matters concerning water issues (ibid., para 12(c)).

The African region has its own regional human rights system. Under this regional human rights system, water is recognised as a human right. The African human rights treaties that expressly recognise the right to life include the African Charter on the Rights and Welfare of the Child (Article 14(2)(c)) and the Protocol on the African Charter on Human and Peoples' Rights on the Rights of Women in Africa (Article 15(a)). These, however, limit the right to water to the categories of people they focus on, that is, children and women. They are not of general application to all the people.

A general direct provision of the right to water in the African human rights framework is to be found in the African Convention on the Conservation of Nature and Natural Resources (2003).[7] Although it is written from the perspective of preservation of nature and the environment, the Convention provides for essential ingredients of the requirements for the right to water in the following terms: 'The Parties shall manage their water resources so as to maintain them at the highest possible qualitative and quantitative levels. They shall, to that effect, take measures designed to:

(a) Maintain water-based essential ecological processes as well as to protect human health against pollutants and water-borne diseases;

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[7] African Convention on the Conservation of Nature and Natural Resources, 2003. Available online: https://au.int/sites/default/files/treaties/7782-treaty-0029_-_revised_african_convention_on_the_conservation_of_nature_and_natural_resources_e.pdf (accessed on 19 September 2021).

(b) Prevent damage that could affect human health and natural resources in another state by the discharge of pollutants; and

(c) Prevent excessive abstraction, to the benefit of downstream communities and states (article VII).

The right to water is also indirectly provided for under the African Charter on Human and Peoples' Rights. This is primarily accomplished under Article 16, which guarantees the right to the highest attainable state of mental and physical health. The relationship of this right to the right to water has been articulated in the jurisprudence of the African Commission on Human and Peoples' Rights in a plethora of decisions. Three cases can be discussed here to elaborate. One of the leading cases is that of *Sudan Human Rights Organisation and Centre on Housing Rights and Evictions (COHRE) v. Sudan 279/03-296/05.* In this case, it was alleged that the government of Sudan was complicit in the destruction of wells and poisoning of water sources in the Darfur region. The African Commission on Human and Peoples' Rights, having established the facts, held that the misdeeds of the government predisposed the victims to serious health risks and was, therefore, a violation of their right to the highest attainable mental and physical health, as provided for under Article 16 of the African Charter on Human and Peoples' Rights (ibid., para 211 and 212). In another case, that of *Free Legal Assistance Groups and Others v. Zaire Communication 25/89, 47/90, 56/91, 100/93 (1995)*, the African Commission on Human and Peoples' Rights asserted that Article 16 of the African Charter on Human and Peoples' Rights obligates states to ensure that every individual shall have the right to enjoy the best attainable state of physical and mental health and that States Parties should, therefore, take the necessary measures to protect the health of their people. In the view of the Commission, the failure by the government to provide basic services such as safe drinking, among others, constitutes a violation of Article 16 of the African Charter (ibid.).

The case of *The Social and Economic Rights Action Centre and the Centre for Economic and Social Rights v. Nigeria 155/96*, dealt with the pollution of the environment resulting from oil mining in Nigeria. It was alleged that the extraction of oil operations had caused massive environmental destruction and health challenges emanating from the contamination of the environment in the region of the Ogoni People of Nigeria and that oil had been exploited without any due regard for the health, well-being, and environmental safety of the local people. This was premised on the fact that the concerned companies, with the complicity of the government, were disposing of toxic wastes into the environment and local rivers and other waterways in violation of applicable international environmental standards. The mining companies were also alleged to have acted negligently by failing to ensure that their facilities did not cause spillages in surrounding villages. These factors resulted in contamination of water, soil, and air, which has led to serious short and long-term health impacts. These include skin infections, gastrointestinal and respiratory ailments, as well as increased risk of cancers, and neurological and reproductive problems. The Commission held that the Nigerian government had a duty to protect its citizens, both through legislation and its effective enforcement, as well as protecting them from damaging acts that may be perpetrated by private parties or entities such as oil extracting companies.

The jurisprudence of the Commission, based on the African Charter on Human and Peoples' Rights, has an inherent weakness—namely, that the right to water is derivative of other substantive and directly protected rights, such as the right to health and dignity. From this angle, it is somewhat a subordinate right that is dependent on the articulation of the parent right. Takele Soboka Bulto has, therefore, argued: 'As the human right to water is protected through other rights, the human right to water is a derivative or subordinate right, the violation of which can only be complained of when the parent rights are violated. In this sense, the relationship between the human right to water and its source (parent right) is such that the former is a small subset of the latter' (Bulto 2011).

In 2015, the African Union adopted a resolution recognising the right to water and enjoining member states to 'protect the quality of national and international water resources and the entire riverine ecosystem, from watersheds to oceans' and to 'guarantee the justiciability of the right to water' (AU Resolution 300 on the Right to Water Obligations ACHPR/Res.300 (Ext.OS/XVII) 2015, para i and v).[8] The resolution, however, is not binding law. However, although it is not binding, it can be argued that to the extent that the resolution articulates the right to water based on binding AU statutes and precedents, it is giving effect to what is already binding those statutes and precedents.

Human rights impose both negative and positive obligations on states. In relation to the right to water, as in relation to other social and economic rights, states have four categories of duties. These are the duties to respect, protect, promote, and fulfil the right to water. There is no hierarchy between these duties.

The obligation to respect is generally considered to be a negative duty. This is because it is said to simply require the concerned state to simply refrain from

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[8] AU Resolution 300 on the Right to Water Obligations ACHPR/Res.300 (Ext.OS/XVII) 2015. Available online: https://www.achpr.org/sessions/resolutions?id=149 (accessed on 19 September 2021).

interfering directly or indirectly with the enjoyment of the concerning economic, social, and cultural rights. The duty to respect means the state is enjoined to respect the freedom of individuals and peoples to use all of the resources at their disposal to meet their economic, social, and cultural needs and obligations as they see fit but within the confines of the law. However, this duty is not just negative because in certain circumstances it may require the state to take positive action. The state, for example, may need to take action to ensure that it passes appropriate legislation to guarantee the right to safe and clean water or to provide standards for the provision of water services for the private sector (ibid., para 5). The second duty is that of protection. This duty entails that the state acts deliberately by taking a positive measure to ensure that non-state actors such as corporate entities and individuals or even government agencies do not violate human rights, and if they do, a mechanism of redress is provided. The duty invariably includes providing a regulatory framework and monitoring mechanism for commercial and other non-state actors that may have an effect on the enjoyment of the people's rights (ibid., para 7).

Finally, states are under a duty to promote economic, social, and cultural rights. This requires states to adopt means or measures to enhance the people's awareness of their rights and to provide accessible information relating to the programmes and institutions adopted to realise the rights (ibid., para 8). This duty requires states to take positive steps in order to realise the people's rights. This obligation is 'a positive expectation on the part of the State to move its machinery towards the actual realisation of the rights' (ibid.).

3. Enforcing the Right to Water: The Case of Vedanta PLC, a Polluting Mining Conglomerate

3.1. The General Context of the Case

The impact of mining on both ground and surface water is well known. This is because water emanating from mining activities may be discharged into both surface and underground water sources. Such water often contains solid and other pollutants, which may make the water acidic, toxic, and unsuitable for human consumption and usage (Karmakar and Das 2012; Hall and Lobina 2012; Younger and Wolkersdorfer 2012; Montejano 2013). Often, this means that polluted mine water is discharged into a river near a mining site or some other surface body of water.

In the Zambian context, the water pollution and environmental problems have largely been associated with the Copperbelt Province, where large-scale mining of copper has been occurring since the 1920s (Lindahl 2014). As a result of mining, it is estimated that more than 10,000 hectares of land in the Copperbelt Province is covered with mineral waste (ibid.). This often leads to contamination of freshwater sources with pollutants, depriving local communities of clean water and presenting an incessant potential for health problems. This is also compounded by the fact that the mining activities are located within the catchment area of the Kafue River, the main source of water for local communities. As a result of the mining activities, the Kafue River and surrounding tributaries are under continuous threat of pollution (ibid.). This situation presents a significant challenge for people who depend on water sources that may be polluted due to mining activities. As discussed, the challenge faced by many local people who may wish to enforce their right to clean water is the lack of systemic enforcement of the law, lack of easy and clear mechanisms for enforcing the right to water in the Zambian domestic sphere, insufficient capacity and rampant corruption by public officials, and an inadequately oriented justice system.

Vedanta PLC is the parent company of a multinational group, which for many years was listed on the London Stock Exchange, with interests in minerals, power, oil, and gas in four continents. It is incorporated and domiciled in the United Kingdom but with operations across the globe. It has a subsidiary and controlling share interest in Konkola Copper Mines (KCM), the largest copper mine in Zambia, which it acquired in 2004 (Das and Rose 2014). The Zambian economy is heavily dependent on copper mining. Copper accounts for about 75 per cent of the country’s export earnings (ibid.). Due to the heavy reliance on copper, mining companies in the copper sector invariably play important roles in the country’s economy and, consequently, in the political discourse of the country. The enormous financial muscles of mining companies often leave ruling political elites and government institutions beholden to the mining companies and, therefore, unable to effectively supervise mining activities to ensure they comply with the law and especially with environmental standards.

Konkola Copper Mines (KCM) is the subsidiary of Vedanta PLC in Zambia. KCM, since its acquisition by Vedanta Resources PLC in 2004, has, with impunity, been polluting the environment around its mining areas. Extensive and consistent instances of air pollution have been documented around KCM’s smelter in the town of Chingola in the Copperbelt Province of Zambia. The mining activity has been consistently discharging toxic fumes of sulphur dioxide beyond the allowed limits, leading to environmental degradation in the surrounding areas of Chingola (Foil Vedanta 2020). KCM has also been discharging dangerous chemicals into the surrounding streams, leading to the death of fish, inability to use the water for farming, and contamination of the water (Foil Vedanta 2020). The people have often been left without clean drinking water. It has been estimated that the contamination of the rivers, including the Kafue River, indirectly affects up to 40 per cent of the

Zambian population, which depends on the same river for clean water for drinking and domestic use. Not only has the contamination of the streams denied the people a clean source of water, but it has taken the livelihood of surrounding communities who are predominantly small-scale farmers, as they cannot rely on fishing and farming anymore for survival. Pollution has also had a deleterious effect on the lives of people by causing multiple diseases and health complications (ibid.).

KCM has not, in any meaningful way, been held accountable for these activities. It has largely been able to continue conducting its affairs with impunity. The economic power of the mine makes it possible for it to capture the ruling elite and shield it away from accountability. A Judge of the High Court aptly opined: 'The only hypothesis for a powerful multinational to supposedly act with impunity and immunity, is that they thought they were politically correct and connected' (see the case of *James Nyasulu and 2000 Others v. Konkola Copper Mines PLC and Others 2007/HP/1286 (2011)*). The shielding of KCM from accountability can also be inferred from the fact that in 2017, a lawyer from Leigh Day, who was meeting the victims of the pollution to brief them on progress on their case in the United Kingdom, was arrested by the Zambian police. The vehicle in which the police officers came had labels indicating that it belonged to KCM (Lusaka Times 2017; Leigh Day 2017). It is presumably this situation that prevented the government from taking any meaningful measures to stop the environmental degradation and, for our interest, water contamination and pollution. Without any meaningful help from the government, in order to vindicate their rights, the affected members of the community had to mobilise themselves to seek redress in court.

It is in this context that the cases discussed below should be understood. The cases relate to members of the community who mobilised themselves to seek redress in court for contamination of their water by KCM and the resultant illnesses they suffered. It should be noted that the Zambian Constitution does not expressly include the right to water. As a result, the most viable way to affect the people was to approach the courts on the basis of the common law tort of negligence by arguing that the mining companies had a duty to care for the affected communities, which was breached. Although Zambia has legislation on environmental management, enforcing its standards is heavily dependent on public officials and not individual members of society. This often leaves affected citizens with limited avenues for seeking redress when their water sources are polluted by the mines.

3.2. The Cases

The major act of pollution which gave rise to the cases occurred in 2006. The accused filed their first case in the Zambian High Court in 2007, which was only determined by the Court in 2011, in favour of the community members. Thereafter, KCM appealed to the Supreme Court. The Supreme Court agreed with the High Court in finding the mining company liable but significantly reduced the compensation payable, making the victory of no consequence. Unable to find meaningful justice within Zambia, the communities, with the help of a pro bono law firm (Leigh Day) in the United Kingdom, brought an action in 2016 against the parent company, Vedanta Resources PLC, incorporated and headquartered in the United Kingdom. The action in the UK was opposed by Vedanta and the Zambian government, mainly on the ground of lacking jurisdiction. This preliminary issue proceeded all the way to the United Kingdom Supreme Court and was determined in favour of the community members, allowing the matter to be heard by the United Kingdom courts in 2019. The main matter is yet to be determined. These cases illustrate the challenges community members face to vindicate their right to water when the contamination of the water is caused by a powerful mining conglomerate. These cases are discussed in detail below. However, it must be mentioned that KCM was expropriated by the Zambian government in May 2019, although the expropriation was still subject to litigation at the time of writing, and the reasons for the expropriation are entirely irrelevant to the enforcement of environmental standards.

The first case is that of *James Nyasulu and 2000 Others v. Konkola Copper Mines PLC and Others 2007/HP/1286 (2011)*. The action, in this case, was brought by James Nyasulu, together with 2000 other members of the community affected by the pollution caused by KCM. The plaintiffs were all residents of the town of Chingola, where the KCM mine is located. The residents' main source of water was a stream in which KCM was discharging the affluence from its mining operations. It was alleged that on 6 November 2006, one of the KCM's tailings pipelines raptured, leading to the discharge of effluent which was high in acidic content into the river. This led to the pollution of the water source in the streams and other rivers downstream, including the Kafue River which supplies water to about 40 per cent of the Zambian population. On 8 November 2006, the Environmental Council of Zambia (now Environmental Management Agency), the main statutory body responsible for environmental management in the country, wrote the KCM instructing it to cease operations of its tailings leach plant in view of the pollution of the Kafue River. The instruction was not heeded. After consuming the polluted water, the respondents suffered from varying illnesses.

The High Court Judge found against KCM. The judge asserted that there was gross recklessness in the operation of the mine in relation to polluting the environment, as the mine did not seem to care whether human beings died or not, wantonly contaminating the water sources for the people. The judge emphasised that by polluting the environment and contaminating the water, KCM deprived the people living in the surrounding areas of the right to life, which the judge considered to be a fundamental constitutional right. The judge was appalled by the behaviour of KCM, asserting that the company bore 'moral, criminal and civil liability for this appalling tragedy' (ibid.). The despicable disregard for human life by KCM was succinctly stated by the judge in the following terms: 'Here is a Multinational Enterprise, which has no regard for human life for the sake of profit and turned the residents of Chingola into "Guinea Pigs" and showed no remorse. In their countries of origin such recklessness would have been visited by severe criminal and civil sanctions' (ibid.).

The judge hypothesised that KCM's impunity was a result of its political influence and connections, which made it feel immune from accountability. Having found against KCM, the High Court Judge ordered KCM to pay K 4 million to each of the 2001 plaintiffs, as general damages, and K 1 million as punitive damages. The total figure came to about K 10 billion (about USD 2 million) (ibid.). The judge indicated that this was necessary in order to deter similarly situated entities from wanton destruction of the environment, human life, and animals.

The judge asserted that the only hypothesis for a powerful multinational to supposedly act with impunity and immunity was that they thought they were politically correct and connected. However, the judge affirmed that the courts have a duty to protect poor communities from the powerful and politically connected. The High Court agreed with the plaintiffs' pleadings that KCM was shielded from criminal prosecution by political connections and financial influence, which put them beyond the pale of criminal justice. The judge asserted that the fact that Zambia was in dire need of foreign investment to improve the well-being of its people should not mean the people should be dehumanised by 'greed and Crude Capitalism, which puts profit above human life' (ibid.). The decision momentarily gave the people a sense of having achieved justice. However, KCM appealed to the Supreme Court.

The second case, that of *Konkola Copper Mines PLC v. James Nyasulu and 2000 Others Appeal No. 1/2012 (2015)*, was filed in the Supreme Court in 2012, challenging the decision of the High Court. It was finally determined in 2015. Although the Supreme Court agreed with the decision of the High Court with regard to contamination of the water and that KCM was responsible, it reversed the order for damages as determined by the High Court. The Supreme Court took a very narrow legalistic approach to the quantification of damages. It held that the judge based his decision to award damages on 12 unidentical medical reports; that is, there were no medical reports supporting the claims of the rest of the plaintiffs, and, therefore, their illnesses resulting from the contamination of their source of water, was not proved. They had not suffered a personal injury.

According to the Supreme Court, once the High Court had established that KCM had polluted the water source, he should have referred the matter to the Deputy Registrar of the High Court for assessment of damages. The Supreme Court reasoned that ordering damages, as the High Court had ruled, could have 'the danger of conferring a benefit on other respondents, who would not otherwise have been entitled to such damages depending on the extent of the injury suffered' (ibid.). The consequence of the decision was that only 12 people would receive very modesty compensation, which in no way reflected the gravity of the contamination of water sources for the people.

Unable to obtain justice from the Zambian Courts, the members of the community looked for avenues of holding KCM accountable beyond the Zambian jurisdiction and commenced an action in court in the United Kingdom against Vedanta PLC, the parent company for KCM in Zambia. Pamela Sambo has argued that it is the failure of the Supreme Court to find an appropriate remedy and the inadequacy of the remedy the Supreme Court ordered that forced the victims to seek justice outside the country: 'This omission, together with the aspect of the inadequate damages eventually awarded to the claimants who lost their livelihood as subsistence farmers led to a multiplicity of actions in search of justice outside this jurisdiction' (Sambo 2019). In 2016, they filed a suit for compensation in the United Kingdom, with the help of Leigh Day, a pro bono law firm. The action in the United Kingdom targeted the parent company, Vedanta Resources PLC, which is incorporated in the United Kingdom and was then the holding company for KCM. When the case was filed, Vedanta opposed mainly only the ground that the British Courts had no jurisdiction to hear the matter, as the Zambian Courts were better placed. This objection proceeded all the way to the United Kingdom Supreme Court. It was finally determined in 2019 in the case of *Vedanta Resources PLC and Another (Appellants) v. Lungowe and Others (Respondents) [2019] UKSC 20.* The UK Supreme Court decided in favour of British Courts hearing the matter, thereby clothing the British Courts with the necessary jurisdiction to determine the main matter. The case was then remitted back to the lower court to hear the case on merits.

In coming to this conclusion, the Supreme Court was, among other factors, influenced by the fact that there was cogent evidence that there was a real risk that substantial justice will not be obtainable in that foreign jurisdiction in Zambia. This, however, did not mean a lack of independence or competence of the Zambian judiciary. This derived from two concerns: 'first, the practicable impossibility of funding such group claims where the claimants were all in extreme poverty; and secondly, the absence within Zambia of sufficiently substantial and suitably experienced legal teams to enable litigation of this size and complexity to be prosecuted effectively, in particular against a defendant (KCM) with a track record which suggested that it would prove an obdurate opponent' (ibid.). The Supreme Court concluded that there was a possibility based on this that the plaintiffs could not obtain substantial justice. The fact that only 12 people in the original Zambian case had medical certificates or medical evidence was telling. It was also felt that the Zambian legal profession lacked the resources and experience with which to conduct such litigation successfully.

Although the main matter is yet to be determined by the United Kingdom Courts, the fact that the Supreme Court allowed the case to proceed is a preliminary victory for the plaintiffs, as it provides a possibility of a decision that will vindicate their rights and particularly hold Vedanta and KCM accountable for polluting the water sources of the people. The decision of the Supreme Court was welcomed by the members of the community. Paul Nyasulu, who was the main plaintiff in the first High Court case, reacted as follows:

> The Supreme Court judgment will finally enable justice for the thousands of victims of pollution by KCM's mining activities, who have suffered immensely since 2006 to date, in the Chingola district of Zambia. Their livelihoods, land and health have been irreparably damaged by pollution which has rendered the River Kafue completely polluted and unable to support aquatic life. Some have already died as a result. We are very grateful to the British Supreme Court for allowing the case to be tried in the UK where we trust that justice will finally be done. As our thirteen years of legal battles have shown, we have been unable to get justice in Zambia. (Foil Vedanta 2019)

Although the decision of the UK Supreme Court now offers the possibility of substantial justice to the community members whose water sources were polluted by KCM, the length of the process, which started in 2006 and had not concluded by 2019, demonstrates the real challenge faced by ordinary community members to enforce their right to water against a powerful multinational.[9] The cases also implicitly demonstrate the failure of Zambian institutions, and consequently the Zambian government, from protecting the people's right to water.

4. Conclusions

Water is a fundamental human right. Without it, other rights would suffer. Having it as a right, however, is not adequate, as there are still practical challenges many poor people face. This often includes finding redress when the natural sources of water are polluted by mining corporations. This chapter brought these practical challenges to the fore. The chapter gave an overview of what constitutes the right to water under international human rights law. It specifically discussed the challenge the victims of KCM's water pollution faced to vindicate their right to water. The chapter demonstrated the challenge poor people face against a more powerful mining conglomerate. With limited resources, corrupt or compromised government institutions, and inadequately acquainted legal profession, fate coalesced against the community members. The government failed to come to their aid. The Zambian judiciary, too, was unable to provide substantial justice to the victims. The picture one perceives from the case analysis is one of systemic failure of public institutions to defend the right to water of poor people. This allowed the mining giant to continue to pollute the water sources with impunity. All the institutions that should have helped to defend the right to water of the poor people seem to have contrived against them and left them at the mercy of the culprit mining company, without any effective remedy. In order to gain appropriate redress, the victims had to approach another jurisdiction, the United Kingdom, where the Courts were more responsive.

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[9] In January 2021, Vedanta settled the matter of out of court and brought an end to the case filed in London. The terms of the settlement, however, are not disclosed and remain confidential.

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