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Digital Technologies for the Future of the Water Sector? Examining the Discourse on Digital Water

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ABSTRACT

Global climate change increases the uncertainty about water, its availability and quality. Thus, the water sector is being transformed to react to the rising water demand as well as climate change and water quality issues and is transitioning into its so-called „fourth revolution“: aiming towards a more sustainable and resilient management of water, whilst simultaneously encountering the mega-trend of digitalisation. Through adopting digital technologies, the sector has the opportunity to address the 21st-century water risks early on as the new technologies will increase the knowledge of water supply, water demand and other water data which can be used to inform public policy or new investments.

In this paper, I critically examine the discourse on digital water and how it is expressed, through the lens of Political Ecology. This is enriched through insights of Science and Technology Studies (STS). The discourse on digital water is characterised by two distinct argumentative pathways: On the one hand, technological solutionism presents digital technologies as the only solution to the challenges within the water sector, and on the other hand, socio-technical imaginaries of the future which constitute digital water as a new pathway within the water sector. This portrays a positive and optimistic future for the development of the water sector which is achieved through the implementation of digital technologies.

1. Introduction

Water, as well as our relationship towards it, is being transformed to react to climate change, rising water demand, and quality issues (Sarni, 2020). This transformation is driven by the increasing implementation of digital technologies — these comprise both hardware and software. Digital technologies include, for example, smart pumps, water meters and sensors to measure, different aspects of water quality. The implementation of software is also part of establishing digital technologies in the water sector, these software solutions can monitor the water flow through the network using artificial intelligence or machine learning and are able to model and predict the water demand in an area.

Yet, the water system is not solely an engineered and technical system, it also holds a social dimension (e.g., needs and values) which also should be incorporated into the management of water (Poch et al., 2020). Digital technologies and innovative strategies to achieve a more sustainable interaction with water are increasingly introduced into the everyday lives of customers. This emergence of digital technologies is not only changing the physical structure and organisational practice within the water sector. It will also alter the customers' perspective on the use of water as well as the relationship between water providers and their customers (IWA, 2019). However, the digital transformation of the water sector will blur the boundaries between engineering and social processes even more due to the technological advancements (Poch et al., 2020).

In this paper, I am taking a close look at the discourse on digital water and how it is characterised, especially focusing on the embedded ‚technological fix‘ thinking as well as the socio-technical imaginaries of the future. This is examined through selected elements of discourse analysis based on the theoretical framework (see Section 2), grounded in Political Ecology (PE), and enriched through insights of Science and Technology Studies (STS). In Section 3 the methods are described before Section 4 presents the key terms of the digital transformation within the context of the water sector's trajectory towards digitalisation. Section 5 then follows with the results of the discourse analysis whilst Section 6 discusses these results before concluding them in Section 7.

2. Theoretical Framework

Political Ecology is an interdisciplinary field and was deeply

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influenced by cultural ecology, political economy as well as development studies and post-structuralism (Benjaminsen and Svarstad, 2018; Neumann, 2009). Especially focusing on the study of power relations of both — human and non-human actors — and the co-production of nature-society relations, whilst examining those relations on different spatial scales (Benjaminsen and Svarstad, 2018). The subfield of political ecology of water focuses on the control over and access to water through the social relations and politics which constitute them (Budds, 2009). This is studied both discursively and materially to concentrate on the politically driven modes of water management (Budds, 2009). Studies concerned with the political ecology of water analyse the relations between its political, social, economic and ecological dimensions and examine how the flow of water is embedded in and influenced through space (Ridolfi, 2014). Studying water and its human appropriation with political ecology leads to a better understanding of the intricate network between actors and their interests (Acharya, 2015).

Hydrosocial research is trying to overcome the nature — society binary through the conceptualisation of water as a social and physical process which is internally combined and produces distinct hydrosocial configurations (Swyngedouw, 2009). Swyngedouw (2009, p. 56) argues that „political–ecological perspectives on water suggest a close correlation between the transformations of and in, the hydrological cycle at local, regional and global level on the one hand and relations of social, political, economic, and cultural power on the other". The hybrid nature of water embodies discursive, symbolic and material processes at the same time (Budds, 2009). Derman and Ferguson (2003), Kaika (2006), Otero et al. (2011) and Mehta (2011) for instance concentrate on different aspects employed to the discourses centred around water ‚crisis' and ‚scarcity'. During the 2016–2018 water crisis, Cape Town used the discourse around the fear of ‚day zero' to introduce a behavioural change in the residents' water use, leading to the practice of water conservation as the new normal (Octavianti, 2020). Furthermore Hommes and Boelens (2018) analyse the discourses furthering the construction of hydropower plants and related development projects in Lima's Rímac watershed.

Water is difficult to study for political ecologists, as it „blurs boundaries" and acts across a wide range of „scales, sites and social actors" (Baviskar, 2007, p. 2), these challenges are an integral part of the material attributes of water (Acharya, 2015). Political ecologists (e.g. Bakker (2004), Ekers and Loftus (2008), Gandy (2008), Loftus (2006) and Swyngedouw (1999; 2004)) studying water analysed the materialities of water and water technologies whilst examining large (urban) infrastructure projects such as dams as well as the impact of urbanization, commercialization, and privatization on water networks (Sultana, 2013). Water infrastructure connects and disconnects people through the extraction, channelling and processing of water and its distribution to different individuals (Guerro, 2018) and reproduces uneven structures between different groups in society. This is supported through the daily management of the water infrastructure as Anand (2017) shows in his book „Hydraulic City: Water and the Infrastructures of Citizenship in Mumbai". He analyses leaks in the water infrastructure and shows how those are utilised by local politicians and engineers to manifest citizenship or to further marginalise social groups (Anand, 2017).

Analysing water infrastructures is not only concerned with the material engagement of the infrastructure itself such as pipes, meters or dams but also with water, its agency and biophysical attributes flowing through those structures, and transforming them (Guerro, 2018). Thus, water infrastructure plays a central role in the material and discursive construction of social relations — within society — which are embedded and conveyed by and through water (Gandy, 2004; Kaika, 2005; Loftus, 2006; Loftus and MacDonald, 2001; Swyngedouw, 2004). It also reproduces power[1] relations, and inequalities within society and changes the relations between the state and its communities (Guerro, 2018; Harris, 2012; Loftus, 2006). Thus, water infrastructures influence social welfare, reproduce (past) ideologies and power relations. This is exemplified by Loftus (2006; 2012) studies on prepaid water meters in post-apartheid South Africa. Hence, water technologies and water infrastructures are not neutral, they are filled with „historical, geographical, political, and social imaginaries" (Sultana, 2013, p. 343) and are therefore also a way of imaging and aspiring the future (Anand, 2012; Gupta, 2015; Howe et al., 2015). New infrastructures are seen as „future proof" by their designers (Edwards et al., 2009, p. 371) as well as „promises made in the present about our future" (Appel et al., 2018, p. 27). Therefore, infrastructures are the material manifestation of future visions and anticipations, however, these cannot persist (Cousins, 2019; Howe et al., 2015; Larkin, 2018). As they are also always situated in the social and cultural setting of their creation and are thus always historically rooted (Howe et al., 2015). This applies not only to built infrastructures but also to „more liquid-like channels of infrastructures [such as] digital flows […] as technology and demands for data […] ebb and flow." (Howe et al., 2015, p. 8). Thus, the construction of infrastructures can be seen as a political–ecological process which encompasses a rearrangement of sociotechnical systems (Cousins, 2019).

Claims, promises and descriptions of possible futures have been studied by the field of Science and Technology Studies (STS). Those statements regarding the future are performative as they not only describe what the future may hold but also that the expectations, visions and anticipations influence what might happen (Konrad et al., 2017). Narratives about the future influence and legitimise research, policies or technologies in different sectors and guide the general societal discourse on how the grand challenges of the 21st century should be addressed (Konrad et al., 2017). STS has investigated the future from different vantage points such as expectations, visions and socio-technical imaginaries. Sociotechnical imaginaries are defined by Jasanoff (2015, p. 4) as "collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." These futures are generally rooted in positive visions of progress thus the term desirable futures is used (Jasanoff, 2015). Studies on sociotechnical imaginaries have mainly concentrated on how the imaginaries legitimise or delegitimise certain future pathways, thus power is deeply embedded within them and also modifies expectations and visions (Konrad et al., 2017). Multiple imaginaries can simultaneously feature within a society, either in a

[1] A broad understanding of power is applied in this article, following the conceptualisation from Svarstad et al. (2018) in their publication „Power theories in political ecology" in which they present three theoretical perspectives of power: (1) actor-oriented power perspectives, (2) neo-Marxist power perspectives and (3) poststructuralist power perspectives. As these perspective overlap, Svarstad et al. (2018) conceptualise power as a combination of those perspectives and call for altering the weight of each perspective based on the (empirical) situation. This plurality of power (theories) within political ecology is a strength, as every approach allows meaningful insights and thus leads to a more diverse understanding of power (Svarstad et al., 2018). In this paper, a combination of those perspectives is used as suggested by Svarstad et al. (2018), focusing on the discursive power perspective — inspired by Michel Foucault. This is conceptualised as part of the poststructuralist power perspectives.

productive dialectal relation or in the form of counter-imaginaries (Jasanoff, 2015). Powerful actors such as courts, institutions or the media then decide over or promote the dominant imaginary for their position and thus influence the broader societal discourse (Jasanoff, 2015). Generally, a sociotechnical imaginary needs to align with the existing cultural norms, values and structures as well as the material infrastructure, economic and political systems to be implemented successfully (Sadowski and Bendor, 2019). Jasanoff (2015, p. 4) emphasises that imaginaries „encode not only visions of what is attainable through science and technology, but also of how life ought, or ought not, to be lived; in this respect they express a society's shared understandings of good and evil.".

Research within STS overlaps and intersects with issues political ecologists engage with, for example, that knowledge is understood as inherently political, the co-production between science and society as well as the situatedness of knowledge (Goldman and Turner, 2011). The field of STS is analysing technology from two different vantage points. Firstly, how the development of new technologies is influenced by humans and secondly, how humans are impacted by the development of technologies e.g. infrastructures, networks or technological systems (Fouché, 2017). Studying those questions reveals the intertwining and complex sociotechnical arrangements between society and technology (Fouché, 2017). To analyse the information infrastructure, a new analytic and methodological focus is necessary as new technologies alter the agency between human and non-human actors since humans increasingly interact with technology in areas where interactions with a person were typical in the past, this resulted in a shift towards studying their assemblages (Slota and Bowker, 2017). Kathryn Furlong (2010) studied the introduction of water efficiency technologies in Canadian water utilities. She showed that the integration of mediating technologies into infrastructure networks leads to shifts in both, the socio-technical and environmental relations within the cities. Furlong (2010, p. 460) defines mediating technologies as „small devices that can be added to an infrastructural network with the intention of modifying its performance (e.g. efficiency technologies)." Thus, digital water technologies such as sensors, digital water meters, pumps or software solutions can be understood as mediating technologies. Coutard et al., (2005, p. 1) argue that water supply infrastructures are „well-developed and long-lasting infrastructures" and are therefore also one of the least flexible infrastructures. Adopting water efficiency technologies can alter the relations between the technical network and other actors such as consumers, institutions or nature within an (urban) water system in planned and unforeseen ways.

In this paper, I will focus especially on the discursive elements from a political ecological perspective which is enriched through insights from STS such as sociotechnical imaginaries (Jasanoff, 2015) and their impact on societies' perception of possible future pathways in the water sector. In the following, this is exemplified in the newly emergent discourse of „digital water" describing the impact of digitalisation within the water sector to advance the literature on water technologies and water infrastructure.

3. Methods

In this article, selected methods of discourse analysis are applied. A discourse represents a certain perspective of a topic that is shared by society or certain groups within the society and is grounded on specific assumptions, arguments and claims which constitute this issue (Fairclough, 2003). Thus, a discourse is a form of social construction where in some cases individual points of view largely impact and contribute to the production, transformation, or establishment of a discourse as well as social structures, institutions, „norms and conventions of both a discursive and a non-discursive nature" (Benjaminsen and Svarstad, 2021; Fairclough, 1992, p. 64). The methodological approach in this article is primarily based on insights from Norman Fairclough's (1992; 2003; 2015) work on critical discourse analysis (CDA). Fairclough (2003, p. 124) understands discourses as „not only represent[ing] the world as it is (or rather is seen to be), they are also projective, imaginaries, representing possible worlds which are different from the actual world, and tied in to projects to change the world in particular directions." According to Foucault (1972, p. 45), the concept of discourse is defined as a way of establishing links between "institutions, economic and social processes, behavioural patterns, systems of norms, techniques, types of classification, modes of characterization". Truths and social realities are produced through the hegemonisation and marginalisation of discourses (Glasze and Mattissek, 2009). Analysing a discourse involves studying the language which is used to share information, ideas and arguments. Through this linguistic analysis, insights on how the discourse structures our perception of those topics, which power structures are embedded within, and which actors dominate and exercise their discursive power through the argumentative structures and used linguistics are generated (Benjaminsen and Svarstad, 2021; van Dijk, 1993). In discourse analysis, power is understood as an inherent component of all social relations, whereby power acts productively and repressively (Fairclough, 2015; Glasze and Mattissek, 2009).

I analysed 89 web texts from websites specifically targeted towards professionals working in the water sector or related sectors such as infrastructure provision or civil engineering, for example, aquatechtrade.com, iwa-network.org, smartwatermagazine.com or waterworld.com. Additionally, texts published by companies providing new technologies for the water sector, such as Idrica or Xylem were also included in the analysis. The texts were published between June 2018 and June 2021, 7 in 2018, 13 in 2019, 35 in 2020 and 34 in the first half of 2021. The increase in published articles indicates a growing interest in and importance of new digital technologies within the water sector. As keywords, „digital water", „digitalisation of water", „digitalisation of the water sector", „digitalisation of the water industry" and „AI for water" were used to find suitable texts for this analysis.

The selected texts were coded and analysed to gain insights into the topics, argumentative and narrative structure as well as the typical linguistic terms utilised within. Tognini-Bonelli (2001) introduced the distinction between corpus-based and corpus-driven studies of corpora. While the corpus-based method works with certain categories and existing theories, the corpus-driven method functions inductively without predefined categories (Mattissek, 2008). The corpus-based approach is a deductive approach, where a specific hypothesis or theory is taken as a point of departure (Meyer, 2014). They systematically search corpora for given phenomena, using the corpus as a source of examples and to either invalidate or verify and quantify the prior made assumptions (Bubenhofer and Scharloth, 2015; Meyer, 2014; Storjohann, 2005). A corpus-based tool is for example the analysis of frequencies of prior determined keywords (Afzaal et al., 2019) — in this case, such as solution(s) with 529, efficiency with 150, innovation with 140 and optimize with 90 mentions. The corpus-driven approach is inductive and thus sets empiricism as the starting point for any analysis and understands the corpus as the foundation to build the hypotheses and theories upon — without prior assumptions and expectations (Bieber, 2015; Bubenhofer and Scharloth, 2015; Tognini-Bonelli, 2001; Storjohann, 2005). For the coding process of the present work, a combination of both, corpus-based and corpus-driven methods was applied. Since there is already prior knowledge about the topic of investigation, a completely inductive procedure was not possible. To avoid a complete restriction to prior knowledge and the resulting categories, the corpus-driven method was used as well to maintain openness. This resulted in the categories technology, challenges in the water sector, solutions for challenges, effects of digital solutions, actors, as well as time and transformation as overarching themes.

4. Water and Digitisation, Digitalisation and the Digital Transformation

Water is defined as „a substance composed of the chemical elements hydrogen and oxygen and existing in gaseous, liquid, and solid states“ (Zumdahl, 2021) since Antoine Lavoisier, discovered the molecule H_2O in the mid-18th century (Ball, 2001; Linton, 2014). Linton (2014) describes this solely physical representation of water (H_2O) as *modern water,* which abstracts water from its historical, social and local conditions and reduces it to a single considerable substance. Digital water draws on this modern understanding of water as H_2O and aims to translate it into the digital space through digitisation.

Digitisation is understood as the technical process which „transforms physical entities into digital objects“ (Rijswijk, 2020, p. 1) and is used among scholars from different disciplines for the process, which converts analogue information into a digital form, so-called binary digits or bits (Tilson et al., 2010). Consequently, the process of digitisation is unprecedented — mediating between the material and immaterial domain — through deconstructing information and transforming it into strings of binary digits (Brennen and Kreiss, 2016). This conversion is accomplished via specific technical mechanisms and infrastructures (Brennen and Kreiss, 2016). Here, algorithms decide what part of the initial information/signal is kept and what is discarded. This selection, which is part of the digitisation process is seen by Katherine Hayles (2003) as a form of „interpretation“. Digitisation within the context of (digital) water can be exemplified with a digital water sensor which for instance measures the salinity of the water. Thus, the information on salinity is extracted and represented in the form of digital data. However, as this sensor only focuses on the salinity, information on pollution, flow data or water temperature is not measured, even though this information is stored within the water. The algorithm, or rather, the people writing the algorithm decide what information is selected (in this example the salinity) and what information is discarded and thus lost within the process.

Digitalisation is in contrast to digitisation not concerned with the process of creating digital data, but with its effects on the modern world impacting society, its structures, and practices (Brennen and Kreiss, 2016). The term digitalisation refers to a sociotechnical process that restructures and impacts social life and institutional concepts to increasingly adopt and depend on digital technologies (Rijswijk, 2020; Tilson et al., 2010). Digitalisation, therefore, shapes, structures and influences countless areas of social life, which is increasingly intertwined with digital technologies and digital media infrastructures (Brennen and Kreiss, 2016). Within the water sector, digitalisation can be seen as the increasing implementation of digital water tools, such as sensors or interactive apps, into the daily relations between water and society.

Rijswijk (2020) understands digitisation as well as digitalisation as part of the digital transformation. These two processes enable an increase in the use and complexity of digital technologies over time, which continuously extends both the positive and negative impacts on society (Rijswijk, 2020). Ossewaarde (2019, p. 24) conceptualises digital transformation as a process „by which social existence is increasingly affected by digital processes, digital tools, and abundance of information“, creating a hybrid world composed of the merging of the physical and digital world. Therefore, changes within society, e.g., social, economic or institutional can increase the demand for new digital technologies. In reverse, the development of digital technologies can also generate those changes within society (Rijswijk, 2020). The digital transformation is also apparent in the water sector. Here, different names exist to describe this phenomenon, whilst the World Economic Forum (2018) describes this development as the „Fourth Industrial Revolution for Water“, The Aspen Institute (2017) calls this the „Internet of Water“. The International Water Association (IWA) coined this phenomenon „Digital Water“ and initiated the „IWA Digital Water Program“ which consists of the publication of various White Papers, Blogs and the DTHub (Digital Transformation Hub) to facilitate the adoption of new digital technologies within the water sector (IWA, 2021). However, none of these terms is concretely defined yet and they all integrate a broad spectrum of different technologies – ranging from sensors and AI to digital twins – without distinguishing these new technologies according to their level of abstraction. Yet, the term „digital water“ is most commonly applied as the IWA is the most prominent and powerful actor in this field. Following this, the discourse on digital water is examined in more detail in the following Section.

5. Discourse on Digital Water

The discourse on digital water analysed in this paper, is currently rooted within the water industry and thus specifically targeted towards people working within the sector or in sectors which are closely related to the water sector. The topic of digital water is introduced mainly through presenting new technologies which are tested, have been implemented or are envisaged for the future and how they will alter and impact the water sector and the work with and within the sector.

The discourse can therefore be divided into three different segments (1) transformation, (2) time and (3) place and scale. In the following, the key themes fostering the transformation towards digital water are presented, as well as the different categories of time and place applied within the digital water discourse.

5.1. Transformation towards Digital Water

The analysed texts can be characterised through their common argumentative structure. At first, the current challenges — climate change, urbanisation, growth of the population and the associated increase in water demand — which the water sector is facing, are introduced. The solution is then directly presented, namely the transformation of the water sector through digital technologies as „the greatest threats to our water supply can be overcome through the application of digital technologies“ (Verma, 2021). Here, a direct link is created between the challenges the water industry is facing and the solutions to those challenges – which always are technological ones. As Guida (2021) states, „digitalisation represents an opportunity to better solve some of the more urgent issues utilities face“. These new digital solutions are not just seen as a better alternative to current practices, but as an inevitable necessity as „[d]igitalizing water and sanitation systems is unequivocally a more efficient way of managing non-revenue water, optimizing water resources and bridging the gap between demand and supply“ (Amengor, 2019). The newly emerging digital technologies in the water sector include sensors, smart pumps, and meters but also software solutions, artificial intelligence or machine learning applications. These are often called digital water solutions, smart water services or digital water technologies. On the one hand, this discourse is characterised through a strong technological lens, on the other, terms closely associated with water are used. Such as, „digital transformation has *trickled* into nearly all aspects of our lives“ (Frigaux, 2020) or „the *flow* of digital water“ (Wirth, 2021). Even though the technological lens, through which water is understood in this discourse, is more dominant and commonly used, the adoption of terms associated with water itself, such as ‚trickled‘ or ‚flow‘ is apparent in the analysed articles.

Next to the challenges and the presented technological solutions, the topic of transformation within the water sector is apparent. Will Sarni (2020) argues that „our relationship with water is undergoing a transformation in response to increased demand for water […], the impacts of climate change and poor water quality“. In response to these challenges, the traditional (analog) water infrastructure is being transformed towards a newly digitalised water infrastructure. The IWA (2021) calls this „[a] paradigm shift for the water industry“. This does not only structurally change the water sector in itself but also, through „introducing new incentives, payment systems, and engagement initiatives would transform the interface between utility and customer and in turn create a new generation of engaged water consumers“ (Sarni, 2020). As new

interactions emerge through digital technologies this also changes the relationship between society and water. Customer engagement is improved through new technologies such as smart meters or apps, which are seen as new tools providing „customers with real time meter readings, allowing the customer to stay on top of their water usage and help minimise their bills“ (Pordage, 2020). This also aims to introduce behavioural changes regarding water consumption „water utility companies are beginning to establish innovative strategies to help engage consumers and restructure the way people think about water use“ (Sarni, 2020). However, this is only achieved if the data — collected through the new mediating technologies (Furlong, 2010) — is shared transparently with the customer in connection with awareness campaigns on water consumption and not solely enacted through adjusting water tariff structures to increase profits for the water companies.

5.2. Time

The topic of transformation also carries the notion of time with it, as this transformation process can be seen as the step linking past, present and future decisions and the resulting pathways together. In the discourse on digital water, time is visible in three distinct conditions. The past (1), is represented through the old or conventional infrastructures and policies which still impact today's water management. The present (2) is represented in two distinct temporal dimensions. Firstly, the present time we live in, in which we face problems such as climate change and growing water demand, and secondly the now. Here, digital technologies operate in real-time,[2] allowing ‚instant' feedback between the involved actors. Lastly, the future (3) is portrayed as a place where the new and emerging digital technologies will have solved all present and past problems.

Next to these three different conditions of time (past, present and future), the discourse builds a dichotomy between the old and the new or the past and the present/near future. Meena Sankaran (2021) argues to „leave behind antiquated notions of incremental change and implement bold new strategies“. The old is connected to negative developments such as mismanagement or water crisis, whereas the new digital technologies are related to better water quality and proactive water management to prevent those past crises (Sankaran, 2021). Water infrastructures are historically rooted and simultaneously also material manifestations of future visions (Cousins, 2019; Howe et al., 2015; Larkin, 2018). Therefore, the introduction of digital water technologies also reveals that the historic way of building and managing water infrastructure is not creating enough data insights to manage the current and future challenges in the water sector. The discourse states those new technologies as the way to not only solve those challenges but at the same time create a better vision of the water sector in the (near) future. This is exemplified by Grievson (2020), arguing that „[i]nstrumentation, as a data source, is one of the fundamental building blocks of a future ‚digital transformed water industry'".

However, this transformation — from old to new — is not aimed to be a slow „evolutionary" adoption of those new digital tools but a fast one. This can especially be seen by the use of the term leapfrogging. Sarni (2020) uses the term and argues that „digital technologies will enable *leapfrogging* of traditional infrastructure (e.g. centralized systems) to hybrid (e.g. centralized and decentralized) and new systems (e.g. off-grid)" as well as Verma (2021) with „[d]igitisation in the water sector *leapfrogs* traditional infrastructure to hybrid and latest systems, provisioning real-time information regarding water quantity and quality for consumers". The aim to develop the water sector fast, instead of incremental, implies a sense of urgency to adopt these new technologies to be able to fulfil the portrayed vision of the future as fast as possible. As „the need of the hour is to build a holistic digital roadmap to set the beginning of the digital water" (ETEnergyworld, 2020) and „there is no better time for governments and the utilities sector to leverage digital water technologies" (Frigaux, 2020) shows how this urgency is implied, whereas Sarni (2020) calls for the implementation of „new tools to accelerate the adoption of digital water technologies".

5.3. Place and Scale

Through the adoption of digital technologies, it is possible for data to easily be „collected and shared at local, regional, and even global scales" (Sarni, 2020). This also allows professionals in the water sector to analyse data on different geographical scales and thus be able to better manage their water. Verma (2021) argues, that technologies such as smart-water meters not only allow real-time monitoring of water data but also enable remote monitoring. Therefore, shifting water management from a place-based monitoring perspective to remote non-place-based management. In the discourse on digital water, this is seen as one of the biggest improvements for the industry as experts can for example monitor water quality data from multiple sources at the same time. However, this shift also introduces new actors and rearranges the power structures from local to remote operating actors, altering the management and monitoring of water and delocalising the decision-making process.

Generally, the discourse on digital water remains very abstract and does not go into detail on what kind of water, for what uses, where, by whom (e.g. water system managers in the global north vs. water users in the global south) and so on is exactly meant. This can be seen in statements like „[d]igital technologies offer unlimited potential to transform the world's water systems" (ETEnergyWorld, 2020). Water itself is generalised as different forms of water e.g. freshwater, stormwater, and (treated) wastewater are mentioned but often not clearly differentiated. A distinction between different geographic areas and their specific challenges regarding water is generally not made within the analysed texts. Even when the differences are addressed, digital technologies are seen as the best solution for the specific challenges as „Countries in Asia Pacific, with vastly different social and economic requirements, are well positioned to adopt digital transformation" (Currie et al., 2020). This may be due to the fact, that the discourse is mainly led by the technology-providing companies (e.g. ABB, Black & Veatch, Xylem) and the IWA. With the goal to implement their technologies in numerous water systems around the world to operate profitably as a company. As many technologies are still piloted or in early implementation stages, the projects predominantly occur — at the moment — on the municipal or regional scale, whereas the overall argumentation regarding the implementation of digital technologies in the water sector is mainly set on a global or supranational scale (e.g. Dedieu, 2021).

6. Critical Discussion

In the following, the results of the analysis presented in Section 5 are critically discussed. Power and its effects are an integral part of political ecological studies (Bassett and Peimer, 2015, Benjaminsen and Svarstad, 2018; Neumann, 2009) as well as within discourse analysis (Fairclough, 2015; Glasze and Mattissek, 2009). In the digital water discourse along with the implementation of digital water technologies, power can be highlighted on different levels. Firstly, the actors who possess the most discursive power are the IWA as well as leading digital water technology companies for example Idrica, Xylem or Black & Veatch as they work together to introduce and implement these digital technologies to the utilities, water providers and other actors within the field. Initiating a shift within the water industry which is also affecting the consumers as

[2] Real-time is seen by Mackenzie (1997; 2007) as a temporal condition which is fabricated and the computational operations take time to process the data. This „machine time" can be divided into „seek time, run time, read time, access time, available time, real time, polynomial time, time division, time slicing, time sharing, time complexity, write time, processor time, hold time, execution time, compilation time, and cycle time" (Mackenzie 2007:89-90). See also Kitchin (2017) on the realtimeness of smart cities.

well as the water infrastructure. The introduction of new actors and technologies within the water industry — whose infrastructure has historically been inflexible (Coutard et al., 2005) — alters existing power relations and generates new ones between human and non-human actors. Therefore, power is enacted by and through the actors working within the field of digital water in the form of market power.

Secondly, the emerging adoption of digital technologies such as smart water meters will also lead to a shift within the power structures of the water sector and also affect the end consumers. At present, technologies are often introduced that predominantly provide new data sets and consequently valuable insights for the water company and their operational business. „Digital transformation can be a challenging process in any sector and company, impacting the organization in all its dimensions“ (Fragoso, 2020). These changes, also affect the operational staff in their daily work, meaning that they are affected by changing power relations due to the introduction of new digital water technologies.

The installation of smart water meters in customer households allows a direct and fast engagement between the customer, their water usage and the water provider. This relocates the power from the company to the customers and gives them more agency over their own water consumption and enables them to act immediately instead of delayed due to the instant feedback through the smart meters or apps. However, this increase in engagement only applies if the data is shared with the end consumer constructively and insightfully. If this is not the case, the utility or water provider keeps the power — given through the new technologies and their generated insights — and enacts it through existing practices such as water bills or altered tariff structures to introduce behavioural changes (Mangolda et al., 2014; Sahin et al., 2017). Power is demonstrated through the new digital infrastructures which are established by the utility or water provider, thus enabling them to enforce their power onto their customers.

Thirdly, the digital technologies applied within the water sector are based on algorithms which are themselves products of unequal power structures. Algorithms are created from a distinct social context and certain visions of the social world, aiming to produce particular outcomes which are influenced and shaped by different interests and agendas (Beer, 2017). The algorithms themselves were written by programmers, who decided, knowingly and intentionally or not, what part of the information is important and needs to be digitised and which can be dismissed in the process (Brennen and Kreiss, 2016). Therefore, they become an essential part of the social world and are integrated into everyday practices, affecting the coding of new algorithms in return (Beer, 2017). Hence, Beer (2017) argues that algorithms should not be viewed as a separate object existing outside a social context, but rather as a product of diverse social forces. The logic of „modern water“ (Linton, 2014) which sees water as asocial and apolitical is deeply rooted in water infrastructure and the technocratic modes of water management which emerged in the 20th century (Bakker, 2004; Sofoulis, 2005). These are also embedded in the vision of the digital transformation of the water sector (Hoolohan et al., 2020) and thus are ingrained in the algorithms. Digital infrastructures and technologies in the water sector can therefore be seen as sociotechnical interventions altering water politics and governance on different scales (Hoolohan et al., 2020). The increasing application of digital technologies across the water system also alters the creation of value in the water industry (Owen, 2018). As a result, power is operated directly through the digital data in the form of data and also algorithmic sovereignty.

Additionally, the new digital water technologies will introduce spatial changes from place-based to remote monitoring of the water infrastructure, management and control. The adoption and evolution of digital technologies result in an increasing distance between people and water regarding the management and distribution of water. This further deepens not only the spatial but also the relational and emotional distance between water — and its social, cultural and ecological context — and society (Ridolfi, 2014). However, the new digital technologies are also able to introduce new connections between society and water, but those are mediated through the technologies themselves and controlled by the increasing number of stakeholders (technology providers such as IT start-ups, hardware and software manufacturers as well as utilities and (new) regulatory bodies) (Hoolohan et al., 2020). The enactment of power through digital water technologies is demonstrated through regulating the access to water as well as to mediating technologies and also the power to control and create connections and relations between actors.

In the following, the discussion is centred around the two aspects — technological solutionism and sociotechnical imaginaries — which are deeply embedded within the digital water discourse and its practices.

6.1. *the Technological Solutionism of Digital Water*

The critical debate around the concept of the technological fix argues that social and ecological problems can be solved using technologies (Dickel, 2021). At the moment, solutions claiming to create a sustainable future through the adoption of digital innovations such as smart metering or remote interactions with virtual technologies are suspected of merely being technological fixes (Dickel, 2021). These technological fixes ensure, that it is not necessary for society to change their behaviour and way of life as technical innovations secure their current mode of existence (Lyons, 2011). David Harvey (2001), who coined the notion of the „spatial fix“ deliberately aligned it with the idea of the „technological fix“. The ‚fix‘ — regardless if it is spatial or technological — is a structural process producing power and temporarily acts as a solution or stabiliser for the observed case but later leads to new problems (Ekers and Prudham, 2017; Svarstad et al., 2018). Thus, these solutions address the symptoms rather than the causes of environmental pollution and resource consumption (Dickel, 2021). This is also the case within digital water, whereas digital technologies (e.g. sensors, AI models, meters) might allow for better knowledge and monitoring of the water quantity in a region, but they still don’t solve the underlying causes of water scarcity. Rather, they stabilise and conserve the dominant power relations.

The term ‚technological fix‘ originated as a positively connoted concept of rational problem solving and was coined by Alvin Weinberg (1967), he characterises a technological fix as the transformation of a social problem into a technological one. Once the problems are framed technologically, they are easier to define, which in turn also limits the space for solutions, as due to the redefinition only certain technical means are possible to solve the problem (Dickel, 2021; Johnston, 2018). Since the early 1970s the term ‚technological fix‘ is used more critically (Rosner, 2004). According to Rosner (2004, p. 3), the phrase was since then „seen as partial, ineffective, unsuccessful, threatening; one-sided as opposed to holistic; mechanical as opposed to ecological“. Now, if something is regarded as a technological fix, it typically implies a separation of the domains of technology, nature, and society (Dickel, 2021). In the field of Urban Planning and Architecture, the belief in the positivity of technological solutions, which neglected any kind of engagement with consciousness was then termed Solutionism (Murphy, 2012). Solutionism can be defined as the idea that there is a technological fix to every social problem (Morozov, 2013). For Morozov (2013), the ideology of technological solutionism legitimises and sanctions actions that presuppose rather than investigate the problems they seek to solve. Technology as a generalised interpretation and practice of modernity, allows technical applications to appear as solutions to major social problems (Dickel, 2021).

I argue that this ‚technological solutionism’ is also visible within the discourse of digital water. Here, the presented challenges within the water sector (water scarcity, pollution, increasing demand) can only be solved through the introduction of new digital technologies (sensors, digital meters, AI). This solutionist thinking is visible in statements such as „the greatest threats to our water supply can be overcome through the application of digital technologies“ (Verma, 2021). In framing

technologies as the only solution to current and/or future water challenges, the discourse consolidates these thought structures, making alternative solutions or ways to overcome them more difficult to implement or even think about. This is also visible in the discourse analysis as „solution“ and „technology“ are among the ten most common words within the analysed texts. Through these statements and also the introduction of the new term ‚digital water‘, technology is on the one hand directly associated with a socionatural phenomenon (e.g., the hydrosocial nature of water) while on the other is also understood as the only solution to our current natural and social problems (e.g. climate change, increasing water demand). Therefore, this solutionist thinking entails a depoliticising element whilst, applying a political ecological perspective to solutionism allows, to not only uncover these depoliticising elements but also emphasise their embedded power relations.

Additionally, Popartan et al., (2022, p. 7) argue that the introduction of AI decision-making algorithms in the water sector „may consolidate the already reductionist and depoliticised water governance perspective that is dominant nowadays“. It is important to understand, that managing water is not just a technical field, concerned with the provision of water infrastructure, but also a political field as it entails human values, behaviours and organisations. The conceptualisation of the hydrosocial cycle by Linton and Budds (2014) shows that H_2O (the materiality of water) affects and is in turn affected by social power and the resulting structures as well as technology and infrastructure altering the flow of water. As it is a cyclical process they also affect the materiality of water and constitute different meanings and conceptualisations of water in the process. The introduction of digital technologies in the water sector also changes the hydrosocial cycle as the relations are impacted on both the infrastructural as well as social side. In the discourse Severoni (2021) argues that „[d]igitization in the water industry […] makes it possible to use data to identify peaks in household usage, helping people understand consumption trends and change their habits“. In this statement, she shows that in order to use the data — the digital infrastructures (e.g. sensors, meters) need to be established first — social power is exercised to help the people understand and change their habits regarding their water consumption. As a result, water (use) will take on a more prominent role in people’s lives. This emphasises, that the new digital technologies in the water sector do not only alter our actions with water (e.g., water management) and related problems (e.g., water crisis) but also impact the way we — as individuals and society — think and conceptualise water itself. However, further research is necessary to unveil the newly emergent relations constituted through and with the establishment of digital water technologies in the sector — regardless of whether it is hardware or software — as both represent a modification to the hydrosocial cycle.

6.2. Socio-technical Imaginaries of Digital Water

Constructions of the future have notably been studied in STS by Jasanoff and Kim (2015) as well as Beckert (2016). They both criticise path dependency for being too historically deterministic and argue against imaginaries being an individual perspective of understanding a certain vision (Hajer and Pelzer, 2018). Both propose that imaginaries should be analysed from the performance and performativity perspective and highlight the necessity to investigate the institutional or socio-technical context or practice from which shared future visions arise (Hajer and Pelzer, 2018). Beckert (2016) examines how imaginaries of shared economic futures are constructed through specific knowledge instruments. He detects that most major social-theoretical concepts apply the concept of path-dependency to describe the present from the past (Beckert, 2016). In contrast to the historical deterministic perspective applied by Beckert (2016), Jasanoff and Kim (2015) analyse socio-technological systems, by relating imagination to both the material and social dimensions. To emphasise their complexity Jasanoff and Kim (2015, p. 2) define imaginaries as „visions of desirable futures“ which in turn can also stimulate socio-technical developments.

Imaginaries of the future are also transported within the discourse of digital water. Here, a positive image of the future of the water sector is portrayed. This is achieved through the implementation of digital technologies for instance Artificial Intelligence (AI), as „AI has an increasingly important role in the water sector and it is likely to increase in the future“[3] (Guida, 2020). These visions of the future of water are created and distributed through the discourse around digital water itself, constructing a dominant future trajectory for the development of the water sector in the process. According to Delanty (2021, p. 2), the future can be seen as the „product of the present and the choices made in the present“ thus, „the future is now“. Within the discourse of digital water, this path is apparent in statements such as „[t]he water industry is adopting smart solutions for a sustainable future“ (Verma, 2020). Here, the future water utility is imagined that it is operating with smart sensors and other technologies, which are already being adopted in the present day to be able to achieve this desired future. The trajectory of modernisation conceptualises the future through the notion of innovation, progress and improvement always presuming the future will improve from the present, as the present itself has improved from the past (Delanty, 2021; Wagner, 2016). The imaging of the future within the discourse on digital water is not neutral as it conveys a modernisation trajectory (Anand, 2012; Gupta, 2015; Howe et al., 2015). As new technologies are seen as the way to *improve* the water sector and ensure that the sector will be set for the future. This self-introduced path dependency can be seen in the technological solutionism thinking as „monitoring water flow levels through smart meters has become a necessity in today’s world“ (Verma, 2021). Thus, a path of smart monitoring technologies for the future of water is generated and alternatives are discursively excluded. This future trajectory is further emphasised through framings such as „The Future of Digital Water Technology is here“ (Sarni, 2018) or „The future of the water sector goes through digitalization“ (Schneider Electric, 2020). Sarnís statement „The Future of Water is Digital“ (Sarni, 2020) constitutes digital water as a new future-oriented reality and can be seen as a material manifestation of future visions (Cousins, 2019; Howe et al., 2015; Larkin, 2018) as well as a promise to the future of the water sector (Appel et al., 2018). This also solidifies the collective belief in the desirability of technologies and their power to solve our current problems in the future. However, Adloff and Neckel (2019) argue, that the future encompasses multiple trajectories and can also be envisioned in another way.

The doubt, on what the future may hold for society is expressed in many spheres of our everyday lives (Oomen et al., 2021). This uncertainty is especially common regarding the impending threats of ecological catastrophes and social inequality (Krznaric, 2019). Thus, future visions of those risks are intertwined in the public imagination along with visions promoting and evaluating specific technologies (Oomen et al., 2021). This can also be observed in the discourse on digital water as argued in Section 5.1 which closely links the challenges in the water sector with technological solutions. Salguero (2021) states that „[t]here are many threats ahead for utilities, such as […] escalating demand for water, […] due to a growing population; […] overexploited, finite resources, and inefficient and ageing infrastructures. The only tool that companies can rely on to achieve efficient management is the use of new technologies.“ This further emphasises the joint argumentation of uncertainty due to global challenges and risks in the water sector with technologies as the way to achieve this desirable vision of the future. The imaginaries conveyed through the discourse on digital water as well as the anticipated establishment of those digital water infrastructures lead to new forms of power, shaped through standards, rules, and regulations which are institutionalised by technology companies, utilities or other influential actors (Björkman, 2018; Carse and Lewis, 2017; Cousins, 2019; Picon, 2018). Therefore, using the lens of political ecology to examine the evolution of digital water, can generate new perspectives

[3] stated by Prof. Kapelan in an interview with the IWA.

and insights on the different forms of power emerging from and with these new infrastructures and mediating technologies.

7. Conclusion

Looking at the discursive elements of digital water from a political ecological and STS perspective, three aspects should be highlighted. (1) As power plays an important role within political ecological research it is important to emphasise the role of the IWA in framing the discourse around digital water. This is especially visible in the widespread use of the term ‚digital water' itself, as it was introduced by the IWA. They not only coined the term but also influence the overall discourse and thus play a leading role in shaping the future of the water sector. From a political ecological perspective, power is visible in the discourse in the form of market power through the new digital infrastructures, as well as regulatory powers, in managing the access to water, the technologies as well as controlling the relations between the involved actors. Additionally, power is enacted through the algorithms themselves as well as the collective framing of the future through the sociotechnical imaginaries and their pathways within the discourse, which is characterised by a strong technological fix thinking.

(2) Examining relations on different spatial scales, which are central to political ecological studies, as well as place-based and non-place-based practices and actors. In the discourse, a shift from place-based to non-place-based actions can be recognised. As digital technologies allow us to collect and share data more easily between different spatial scales and manage for example the water flow from afar, through remote monitoring. Additionally, new relations are formed through the digital technologies themselves. However, the discourse generalises water and does not differentiate between different water sources, and users or between different geographic areas with diverse challenges for their regional water system (e.g. water system managers in the global north vs. water users in the global south). The analysed texts remain very general and mainly present technological solutions to problems in the water sector but without going into more detail e.g. on local conditions of the water sector. In order to present a more differentiated view of digital water, further research like region-specific case studies are necessary.

(3) Following the intersection of STS and the political ecology of water, even though, the hydrosocial nature of water is not directly addressed in the digital water discourse, a shift is visible. The concept of hydrosociality is concerned with the internal linkage of water and society (Wesselink et al., 2017) which includes water technologies. However, traditional (or analog) water infrastructures (e.g., dams, and canals) have been understood as technologies, in contrast to digital data, sensors or AI. However, if examined from a hydrosocial perspective, these new digital technologies are not (yet) fully integrated into the dimension of technologies. Furlong (2010) showed that mediating technologies such as water efficiency technologies lead to shifts in both, the socio-technical and environmental relations within the cities. These new elements within the water sector, therefore, also need to be incorporated within the framework of hydrosociality as they introduce and coproduce new relations between society, (digital) technologies and water and vice versa. These newly emerging relations between water, society and digital technologies are already visible in the discourses around digital water. However further research is needed to better understand these emerging relations as well as the use of power related to digital water.

Generally, the discourse is characterised by two distinct argumentative pathways: On the one hand, technological solutionism which presents digital technologies as the only solution to the challenges within the water sector, this framing entails a depoliticising and managerial element which can be revealed by examining it through a political ecological lens. On the other hand, socio-technical imaginaries of the future transported through statements such as „The Future of Water is Digital" (Sarni, 2020) constitute digital water as a new future-oriented reality within the water sector. Through this, a dominant future vision for the development of the water sector is established. These emerging framings impact the actors' present and future understanding of water and consequently affect their actions towards water and its management. Ultimately, digital technologies are tools that only ever exist within a social context as well as being historically and geographically specific (Beer, 2017; Howe et al., 2015). The discourse on digital water is at the moment still predominantly taking place within the water industry and aimed at the experts working in the water and related industry sectors and not yet a general discourse within society. Despite that, with more widespread adoption and distribution of these new digital water technologies, the discourse on digital water will most likely start to flow into a more extensive societal discourse and result in altered actions and a modified understanding of water.

CRediT authorship contribution statement

Christina Walter: Conceptualization, Methodology, Writing – original draft.

Declaration of Competing Interest

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

Data availability

Data will be made available on request.

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