Digital Water in Tension

Working Toward Welfare Through Commodification and Collaboration with Smart Water Infrastructures

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DOI (link to publication from Publisher):
10.54337/aau749593216

Publication date:
2024

Document Version
Publisher's PDF, also known as Version of record

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WORKING TOWARD WELFARE THROUGH COMMODIFICATION AND COLLABORATION WITH SMART WATER INFRASTRUCTURES

BY
JONAS FALZARANO JESSEN

PhD Thesis 2024

AALBORG UNIVERSITY
DENMARK

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PhD Thesis 2024

Submitted: July 2024

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PhD Series: The Doctoral School of Social Sciences and Humanities,
Aalborg University

Department: Department of Culture and Learning

ISSN: 2794-2694
ISBN: 978-87-85239-03-7

Published by:
Aalborg University Open Publishing
Kroghstræde 1-3
DK – 9220 Aalborg Øst
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CV

Jonas Falzarano Jessen (born 1992) has obtained his Bachelor's degree in Anthropology from Aarhus University in 2017 and his Master’s degree in Techno-Anthropology from Aalborg University in 2019. His research interests lie in the water-climate-digitalization nexus. Prior to his academic positions at Aalborg University, Jonas has worked with climate change adaptation and citizen involvement projects at a Danish Municipality.

English Summary

The management of water and its infrastructures have always been carried out in networks of humans and technologies where human expertise and skills collaborate with a variety of artefacts and technologies to know, control, and distribute water. From this viewpoint, water management – and the bureaucracy and infrastructure that sustain it – is both a complex phenomenon and one that extends into different domains of the social (Orlove & Caton, 2010). Water supply encompasses local water utilities, national and governmental authorities, and international interest organisations, as well as entangled networks of water pipes and technologies. Furthermore, information about water – availability, demand, flow, usage, and leakage – has been crucial for securing water supply for as long as humans have built infrastructures for water distribution. Human relations to water, one might say, have long been mediated by technologies and information. In recent decades, such information has increasingly taken shape as data, and the sensing bodies through which such information is created are increasingly digital. Digital technologies for water supply and management (and the digital data they generate) are envisioned by their advocates to enable informed decision-making and optimal water supply in an increasingly uncertain world, where economic instability, changing political and environmental climates, and urbanisation threaten to disrupt traditional water supply systems and economic models. For the most inventive, they even promise new global export ventures for Danish enterprises, resulting in economic profit and growth.

This dissertation investigates 'Digital Water' as a phenomenon that denotes the emerging uptake of digital water technologies within traditional water systems and the future aspirations and shifting practices that they engender in the Danish water sector. Based on twelve months of ethnographic fieldwork among water utility employees, IT specialists, water engineers, consultants, computer scientists, and digital water systems, it explores Digital Water as an open system (Fortun, 2003) along three intertwined empirical tensions. These consist of the tension between Digital Water as export and diplomacy, between human and artificial ways of sensing and knowing water, and between anthropology and computational science. Attending to 'Digital Water in Tension', this dissertation offers a prism for anthropology to observe and understand but also to speculate and intervene in Danish water and welfare futures. Seen through this prism Digital Water is more than a model for the betterment of local water supply. Reflecting current neoliberal developments in the Danish Welfare system (Pedersen, O. K., 2011), it also highlights how it functions as a strategy to finance the Danish Welfare Society and sustain its future by expanding its economy. By means of a collaborative, engaged, and yet critical ethnography *with* the diverse actors that compose the 'ecosystem of Digital Water', this dissertation finally shows that there is an urgent need to re-embed a fundamental element of the Danish Welfare model into the making of Digital Water futures: the social.

Danish summary

Styring og kontrol af vand og dets infrastruktur er historisk altid blevet varetaget i netværk der består af menneskelige og teknologiske aktører, hvor menneskelige færdigheder og ekspertise samarbejder med flerartede værktøjer og teknologier for at forstå, kontrollere og forsyne vand. Fra dette perspektiv er vandforsyning – og de bureaukratiske procedurer og infrastrukturen omkring vandforsyning – både et komplekst fænomen, og et fænomen der strækker sig ind i forskellige domæner af det sociale (Orlove & Caton, 2010). Vandforsyning involverer både lokale forsyningsselskaber, nationale og internationale myndigheder og interesseorganisationer, såvel som sammenflettede netværk af vandrør og -teknologier. Derudover har informationer om vand – dets tilgængelighed, efterspørgsel, flow, forbrug, og spild – været afgørende for at sikre vandforsyning siden mennesker begyndte at bygge vandforsyningsinfrastrukturer. Menneskets relation til vand, kunne man være fristet til at sige, er længe blevet medieret af vandforsyningsteknologier og information. I de seneste årtier har information om vand i stigende grad været i form af data, og de former for sansning hvorigennem denne information skabes, er i stigende grad digitale. Fortalerne for brugen af digitale teknologier (og de digitale data, de genererer) i vandforsyningen forudser, at digitale vanddata vil skabe et bedre grundlag for at tage beslutninger omkring driften af vandinfrastruktur samt optimere vandforsyningen i en stadig mere usikker verden, hvor økonomisk usikkerhed, skiftende politiske og miljømæssige klimaer og urbanisering truer traditionelle vandforsyningssystemer og økonomiske modeller. Digitale vandteknologier spås endda at åbne nye globale eksportmuligheder der kan

skabe økonomisk overskud og vækst for de mest innovative danske virksomheder.

Denne afhandling udforsker 'Digital Vand' som et fænomen, der kendetegner udbredelsen af digitale vandteknologier inden for traditionelle vandsystemer samt de fremtidige ambitioner og skiftende praksisser, som de afføder i den danske vandsektor. Baseret på tolv måneders etnografisk feltarbejde blandt vandforsyningsoperatører, IT-specialister, vandingeniører, konsulenter, dataloger og digitale vandsystemer, udforsker den Digital Vand som et åbent system (Fortun, 2003) i lyset af tre sammenflettede empiriske spændinger. De består henholdsvis af spændingen mellem Digital Vand som eksport og diplomati, mellem menneskelige og kunstige former for sansning og intelligens, og mellem antropologi og datalogi. Med fokus på 'Digital Vand i Spænding', tilbyder denne afhandling et prisme, hvorigennem antropologien kan iagttage og forstå, men også spekulere og intervenere i Danmarks vand- og velfærdsfremtid. Gennem dette prisme viser Digital Vand sig at være mere end blot en måde til at forbedre vandforsyning på. Det fremhæver også, hvordan Digital Vand udgør en strategi til finansieringen af det danske velfærdssamfund og opretholdelsen af dets fremtid ved at udvide dets økonomi. Gennem samarbejdende, engageret og dog kritisk etnografisk arbejde *med* de forskelligartede aktører, der udgør 'det digitale vands økosystem', argumenterer denne afhandling endelig for, at der er et presserende behov for at genindføre et grundlæggende element for den danske velfærdsmodel i forbindelse med skabelsen af fremtidens digitale vandsystemer, nemlig det sociale aspekt.

Acknowledgements

This dissertation is a product of the help, encouragement, and support that I have received along the way. This piece cannot possibly acknowledge the many remarkable and inspiring people whose generosity, patience, and reflections have touched me over the past three years or so in an exhaustive way. For now, however, I will have to suffice with these words and hope that the future brings many occasions that will allow me to return at least a fraction of the warmth and availability that I have been blessed with.

I would like to open by thanking the Poul Due Jensen Foundation for funding the interdisciplinary 'Smart Water Infrastructures' (SWIft) project to which this dissertation forms the ethnographic contribution. I also take this occasion to mention my SWIft colleagues: Abhijit, Bulut, Carsten, Rahul, Rafal, and Saruch. Thank you for teaching me that interdisciplinarity is always as giving as it is challenging.

I am also immensely indebted to all the interlocutors that I have encountered and collaborated with during my fieldwork. I cannot overemphasize my gratitude for the time and thought that you have invested in this project. Without you, this dissertation would not have been possible. I owe a special thanks to Liam, the Danish water ambassador at the Royal Danish Embassy in Rome, to Peter from WADE Consulting, and to the employees of Lemvig Water, including the CEO who saw potential in sustaining my research project by giving me a desk at the utility's office, and to Brad for letting me ask 'dumb' questions during our many leakage detection rides in his cargo van.

I owe my greatest gratitude to my two fantastic supervisors Astrid and Adrienne. Thank you, Astrid, for your always enthusiastic and positive state of mind, for seeing possibilities where I saw none, for the always inspiring funky-coffee-infused conversations at the 'kolo', for your flexibility and support through the ups and downs of dissertation writing and, nonetheless, for always being true and transparent. Thank you, Adrienne, for truly being there in the last stages of writing this dissertation, for your always sharp and on-point comments, for killing my darlings, for your honesty, and for your sense of humour.

I am also indebted to my colleagues at TANTlab at Aalborg University in Copenhagen: Ann-Sofie, Alfred, Anders K., Anders M., Carina, Johan, Lasse, Laura, Mathieu, Matilde, Mette, Morten, Sofie, and Torben. I am particularly indebted to our little but strong techno-anthropological team at Aalborg University in Aalborg: Andreas B. & Andreas T., and Pernille. Thank you for the many great conversations, input, and reflections that have helped me sharpen my arguments for this dissertation and helped me generate and think through the ethnographic data that have formed this dissertation.

Thanks to Prof. Tom Boellstorff for showing great interest in my work and for his generous comments and thoughtful input as my supervisor during my four months as a Fulbright visiting scholar at UC Irvine. I hope you had a wonderful trip to Puglia. I also thank Associate Prof. Lilith Mahmud and Prof. Kim Fortun for their input on my work during my time in Irvine.

Finally, I want to acknowledge the tireless support that I have received from my family while writing this dissertation. Tak til dig mor, for din altid skarpe og ultrahurtige korrekturlæsning, og for din støtte når jeg var bange for at miste mit akademiske og emotionelle fodfæste. Grazie a te papá, per essermi

sempre vicino col cuore e col pensiero anche in questi momenti difficili. Nonostante la lontananza che ci separa sei sempre con me. Og sidst, men ikke mindst, tusind tak til dig, Solskin, for at være der for mig i livets op- og nedture. Med dig er livet en leg.

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Chapter 1. Getting our Feet Wet

Back in the day, water utility companies would hide, like we hide water pipes underground. We barely spoke with anybody about what we do, and we only focused on silently managing our community's water network. Today this is fortunately changing, and knowledge and digitalization are paramount to sustain this transformation. […] The government has identified the water sector as a promising field to create a new economy for Denmark by sharing our excellence in water management. But to succeed – and ride the digital wave – we need innovative solutions. And we need to show them to the world!

It is Friday afternoon in the windswept rural village of Lemvig, nestled by the Danish west coast between the North Sea to the west and the waters of the Limfjord to the North. An August sun shines outside of the main hall of the local water and wastewater utility as I listen to the CEO of Lemvig Water open the monthly staff meeting with his employees and the management. Full of hope and promise, the talk of the CEO makes me think of how Danish water management seems to serve a twofold function: to secure local livelihoods and to sustain the economy of the Danish welfare model based on wealth distribution. In the meeting room, however, the atmosphere stands in stark contrast to the sense of aspiration, anticipation, and hopefulness of the CEO. The air is thick with tired employees who, it seems to me, already imagine themselves on their way home after a long week. Eyes rolling. Feet shuffling impatiently. This was not the first time that they had heard their CEO gesture about a grand future for Lemvig Water through technological

innovation. Before the meeting, I had been told about these meetings by some of the employees. The CEO's future visions for the utility seemed very far from their everyday work and took precious time; time that would be better spent, they believed, on some of the pressing water management tasks that help secure the proper operation of the water network.

I start this dissertation about the digitalization of water management in a meeting room at a water utility company on the Western coast of Denmark. A room which is remarkably devoid of water technologies and infrastructure, whether they be digital or not. There are no visible pipes, valves, or pumps. No data centres, computers, or processors are being used, nor are there any remote sensing technologies or advanced monitoring, communication, and control systems. It is a space populated not by software, bits, and digital data. It is, rather, made up of coexisting, albeit also divergent and conflicting expectations, experiences, and narratives about what 'smart' water management is and could be – of what it promises. This is no coincidence. I chose this opening vignette because I believe it encapsulates a central sociotechnical tension that arises in the midst – and as a consequence – of the wave of digitalization that currently affects practices and future aspirations at Danish water utilities. Specifically, it exemplifies how water management in Denmark is strung between two viewpoints that seemingly pull it in different directions. On one hand, we have the daily operation of water supply systems as a public welfare service. On the other, we find the concurrent managerial and strategic work that is put into framing what I address as 'Digital Water' as a critical commodity that promises to finance the costly Danish welfare system and to sustain the steady expansion of the Danish national economy.

As I engaged ethnographically with the phenomenon of Digital Water during fieldwork, I collaborated with an open system in diplomatic, operational, and disciplinary tension. With this dissertation, I show that Digital Water functions as a model to finance the Danish Welfare State and to sustain its economic future. I argue that it does so by reframing how global water infrastructures are commodified, managed, and understood.

Setting the scene: An Anthropology *in/of/with* Digital Water

As I left for my first few months of fieldwork in Lemvig in the summer of 2021, I had the ambition of learning something about how the gradual uptake of digital tools and infrastructures affect water management practices in the context of a peripheral region of Denmark that is particularly exposed to an increasingly unruly and unpredictable climate. Upon returning, however, I was left with other questions that have slowly recalibrated my attention for this dissertation project and projected my curiosity beyond local and national boundaries. What is the relationship between the daily operation of local water supply systems and shifting water politics in the context of increasingly unruly economic and environmental climates? How does the wave of digitalization that is currently investing Danish water management, including the ideas of 'smartification' that accompany it, affect this relation? Indeed, what does it mean to manage water smartly in present-day Danish welfare society, with which implications, and for whom? And how do we make ethnographic sense of the digitalization of water management, when it is not only ongoing and of shifting nature, but when making sense of water, to 'know it' and act upon it – its management, infrastructure, and future history – are altered through the digital?

While large pieces of this dissertation draw on ethnographic fieldwork conducted where it opens: in Lemvig, the story that it recounts cannot be confined to a specific water utility company, nor a single region. By addressing these research questions forthrightly in the following chapters, we will come to see how my first fieldwork experiences have shifted my attention from Lemvig in the classic sense of a bounded field site (Candea, 2007). Instead, I offer an ethnography that sets out to follow the different shapes and material implications of digitalizing water management across a multiplicity of locations, actors, and practices in and beyond Denmark. This dissertation builds on approximately 12 months of ethnographic fieldwork conducted primarily between January 2022 and September 2023 among water professionals, researchers, and IT specialists at water utility companies, universities, private enterprises, interest organisations, consultancy companies, laboratories, and ministries in Denmark and Italy. It draws on detailed ethnographic fieldnotes from participant observation and on countless semi-structured interviews and casual conversations at Danish and Italian water utility companies. It also draws on my participation in national and international water conferences and seminars, international encounters between water professionals aimed at building diplomatic relations and exporting Danish water solutions, and from experimental and trans-disciplinary research situations for collective knowledge exchange and generation.

In answering the abovementioned questions, this dissertation constructs an ethnographic field site by following the emergence and local implications of a complex, heterogeneous, and multifaceted phenomenon: 'Digital Water' across time, space, and different 'scales of attention' (Hastrup, K., 2013). In a sense, thus, this can be seen as a form of multi-sited ethnography (Marcus,

1995). It follows the emergence of a single ethnographic field which is not particularly geographically bounded, namely Digital Water, as it stretches and takes form across multiple and diverse kinds of field sites and actors and as, conversely, it reconfigures everyday practices and relations among them. Within this framework, my overall attention with this dissertation concerns how Digital Water promises to reconfigure regimes of water management (Orlove & Caton, 2010), including infrastructured modes, practices, and expectations of how to make sense and use of water as an element and asset that is (re)made legible through digital data.

Beyond offering an ethnography in and of Digital Water, this dissertation can be seen as an intervention – or even contribution – to its emergence too. This work forms part of a four-year collective interdisciplinary research project called 'Smart Water Infrastructures'[1] (henceforth SWIft) at Aalborg University. The engineering-led research project was aimed at 'optimizing' water flows and management at water utility companies through computation and automation. My role was to bring 'real-life, empirical insights about the social aspects of digitalizing water management' into computational and laboratory studies (Wisniewski et al., 2019). Being an integral part of the SWIft research team has had important consequences for my research strategy. Throughout my fieldwork, I balanced between performing a distanced critique – or ethnography of – Digital Water and a form of ethnography with (Ingold, 2011; Ingold, 2017) my interlocutors and colleagues.

[1] The 'Smart Water Infrastructures' research project, and thus this Ph.D., are funded by the *Poul Due Jensen Foundation*.

As Ingold observes, invoking an anthropology of something bears an implicit objectification of its topic of inquiry. To observe with, instead, 'is to attend to persons and things, to learn from them, and to follow in precept and practice' (Ingold, 2017: 24). I sympathize with Ingold by concurring that in this relation of correspondence with its interlocutors and ethnographic objects lies anthropology's responsibility to take part in future-making practices, or to 'seek ways to answer to the worlding world' (ibid.).

As we shall see, this dissertation is largely the product of ongoing engagements with my interlocutors (including my SWIft colleagues) in collective explorations of what it means to digitalize water management in practice. By taking active part in collaborative reflections and explorations among local epistemic communities (Holmes & Marcus, 2008) at water utility companies, water conferences, and by crafting spaces for shared intellectual explorations my work becomes, as I argue in the following chapters, an ingrained part of the emergence of Digital Water. This has important methodological and analytical implications which I will unfold in Chapter 4 and 6. For now, let me proceed, instead, by offering a working definition of Digital Water.

Digital Water: A Cyber-physical and Open (Eco)system

Digital Water. Smart Water. Internet of Water. Water 4.0. The digitalization of water management goes under many names (CALL Copenhagen, 2018; IWA, 2019; The Aspen Institute, 2017; World Economic Forum, 2018). Common to all of them is the reference to a broad range of technologies imbued with a somewhat techno-optimistic progress philosophy for water management. Albeit their definitions tend to overlap, in this dissertation I use the term 'Digital Water' as authored by the International Water Association

(IWA) because their voice is arguably one of the most influential in the field of water management, being the largest global membership association for water professionals.

Just like its multiple names, what 'Digital Water' entails and how it will be implemented in practice is not clearly defined. 'Digitalization' is a broad term too, which broadly covers the use of digital technology and digital data associated with the change or betterment of organizational and societal processes and practices (Plesner & Husted, 2020). Nevertheless, most of its proponents seem to converge towards seeing it as an interconnected and dynamic cyber-physical ecosystem enabled by the uptake of digital and 'smart' technologies within traditional water infrastructures (IWA, 2019). Digital Water is often described as an ensemble, or 'ecosystem', of interconnected digital sensing devices and automation technologies that promise to offer 'unlimited potential to transform the world's water systems, helping utilities become more resilient, innovative, and efficient, and in turn, helping them build a stronger and more economically viable foundation for the future' (IWA, 2019: 8). This 'ecosystem' (see Figure 1) is envisioned to allow for open engagements with digital datasets from across a multitude of stakeholders and data sources both within and without different water utility companies (IWA, 2019: 13). However, despite most of its proponents claim that 'digital water is already here' (IWA, 2019: 5), it is mainly so on a strategic level as a promise through which leading global water actors envision and enact water management's so-called 'digital journey' towards more energetically and economically efficient water supply. In other words, the ecosystem of Digital Water, as portrayed by the IWA, entails interactions and exchanges of information between different human and nonhuman actors

that promise a more efficient, interconnected, and profitable water management.

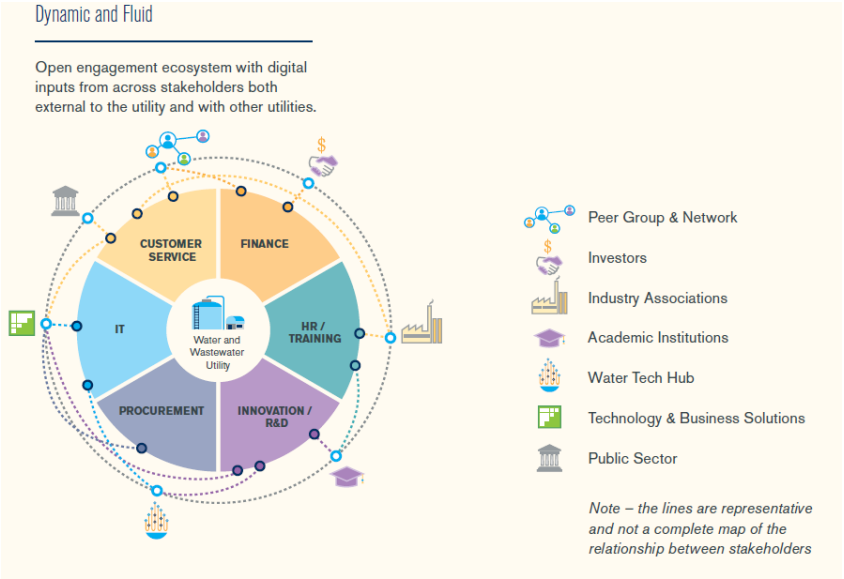

Figure 1: *The ecosystem of Digital Water including its flows of digital inputs as described by the IWA. Credit, IWA (2019: 13).*

As Hannah Appel, Nikhil Anand, and Akhil Gupta (2018) remind us, infrastructures, including water management systems, are 'dense social, material, aesthetic, and political formations that are critical both to differentiated experiences of everyday life and to expectations of the future' (Appel et al., 2018: 3). This richness of materialities, politics, reminisced pasts, experienced presents, and desired futures that are embedded and made actionable through Digital Water lies at the heart of this dissertation and forms my ethnographic object. But by addressing Digital Water as an ecosystem, my aim is not only to think ethnographically with an emic classification that imagines the uptake of digital water systems as being made up of the multiple relations between its material, digital, and human actors. Having an ecosystemic approach to Digital Water also entails an analytical view.

In biology, an ecosystem – or ecological system – encompasses the interrelationships between living organisms and the environment with which they interact (Oxford English Dictionary, 2023). It consists, in other words, of the interactions between interdependent biotic (including human) and abiotic components linked together through nutrient cycles and energy flows. Anthropologist Jennifer Gabrys extends this definition of ecology to include not only environmental ecosystems, but also 'informational and cybernetic management of environments as much as a philosophy of interconnectedness' (Gabrys, 2016: 15). In probing the utility of the concept of ecosystems in the context of studying 'wired up' environments (ibid. 8), Gabrys turns to how natural environments are increasingly 'read through devices such as sensors and satellites, and assembled into networks' that transform them into 'a shifting entity that typically becomes visible – and manageable – as information' (ibid. 15). Building on Gabrys, this dissertation is attentive to the emergence and character of novel intersections between disparate and otherwise disconnected practices that come to make up the ecosystem of Digital Water. Inspired by the work of Tim Ingold (2011) and Sarah Pink (2016), my ethnographic take on the 'ecosystem' of Digital Water is one that wants to emphasize its ongoing growth, movement, and constant state of formation, and how this emergence brings together different actors, human and nonhuman, in disruptive and generative ways.

In other words, I explore Digital Water as an open (eco)system (Fortun, 2003) wherein my research becomes inherently enmeshed by actively taking part in the ongoing, speculative, and grounded experimental exploration of the possibilities and potentials embedded in digitalizing water. According to Fortun, open systems are open-ended objects of inquiry such as global economy, organizations, subjects, or technologies 'that are continually being

reconstituted through the interaction of many scales, variables, and forces' (Fortun, 2009: 74). The task of the ethnographer studying (in/with) such kinds of open systems, Fortun argues, consists of stringing her/his ethnographic praxis out across multiple sites, interlocutors, scholarly domains, and forms of engagement to map the (local and global) constitutive dynamics of a phenomenon. Fortun refers to this approach as an ethnography *as* open system (Fortun, 2003). By this, she conceptualizes an ethnography whose significance lies less in what it concludes than in the discursive resources it provides and the new pathways it opens (ibid. 187). This ethnography *as* open systems, she continues, is devised to 'shape contemporary life' by providing 'openings, images, and discursive resources that enable readers to read the world well enough to make out gaps and fissures from which something new can emerge' (ibid. 188).

Inspired by these scholars and their ideas, I think of Digital Water as an open (eco)system of machinic and human actors. In this sense, Digital Water brings together diverse human and nonhuman actors, discrete and interwoven acting and reacting practices, ways of managing water and data, as well as different unfolding politics of future aspirations and anticipations. Through this lens, I want to tell the story of what happens in practice when water and data practices and infrastructures flow, mix, and mutate; how this interweaving is practically experienced, and how to make ethnographic sense of the resulting socio-technical ensemble. Rather than assessing the viability or validity of the transformations promised by Digital Water, I explore what anthropologists Penny Harvey and Hannah Knox call its 'capacity to enchant' (Harvey & Knox, 2012), or how it holds different hopes, expectations and, I would add, practices of managing and making sense of water together and in tension. I have found the concept of *tension* to be a productive companion to thinking

about Digital Water and a useful device to unpack its multiple empirical facets. Let me therefore introduce how I engage Digital Water with and through tension.

Doing Anthropology in Tension

In physics, tension denotes the pulling force in differing directions at each end of an object – such as a rope – that defines the degree to which it is stretched. This produces a reacting force that simultaneously tends to restore the *status quo* by bringing the ends closer to each other. We all know by experience that exercising a pulling force at each end of a rubber band also produces a reacting restoring force, which works in opposition to the pulling force by trying to restore the rubber band's original state of slack. So, tension refers to a dual pulling force that is exercised on an object by pulling its molecules apart, while also somehow holding them together. Similarly, this dissertation sets out to explore what it means to study Digital Water in tension between multiple pulling forces.

Throughout this dissertation, we shall see how paying attention to different forms of empirical tensions serves as a way to surface otherwise implicit or inaccessible socio-technical phenomena, rendering them accessible to ethnographic scrutiny and engagement. Particularly, I explore Digital Water along three intertwined empirical tensions. These consist of the tension between Digital Water as export and diplomacy, between human and artificial ways of sensing and knowing water, and between anthropology and computational science.

In setting out to investigate the emergence of Digital Water ethnographically by paying particular attention to *tensions* as a means for anthropology to

understand, speculate, and intervene on potential water futures, I am particularly inspired by how anthropologist and thinker-practitioner, Anna Tsing theorizes *frictions*. Anna Tsing has dedicated part of her lifework to studying the inner workings of capitalism, global connections, and the unexpected corners of commodity chain mechanisms (Tsing, 2012; 2015). These studies demonstrate how global connections of capitalism do not operate smoothly and independently. On the contrary, they are held together by friction (Tsing, 2005). Tsing perceives friction as a metaphorical image for the productive 'grip', or the interferences and patchworked economies and practices that operate at the edges of capitalist dynamics but which, nonetheless, make global connections, trade, and commerce possible. Furthermore, she attends to friction as an inlet to give 'an ethnographic account of global interconnection' (ibid. 6). Studying 'zones of friction' ethnographically, understood as spaces where encounters and interactions between different actors make space for awkward, unequal, unstable, and creative engagements through which 'cultures are continually co-produced' (ibid. 4) unlocks, according to Tsing, the possibility of studying abstract claims as they operate in the world in practice.

Accordingly, as we move through the chapters and articles of this dissertation, we tack back and forth between diverse sets of tensions that, I argue, render Digital Water ethnographically accessible as a phenomenon in the world, and reveal how it operates in practice. I hope to show not only how the digitalization of water brings otherwise disconnected actors and practices together, but also that this movement corresponds to a shifting ethnographic attunement to various sets of socio-technical and epistemological tensions that open for different layers of analysis – and of anthropological intervention. I argue that these tensions, through the very forces that pull Digital Water in

different directions, are also what hold it together, surfacing novel ways of doing and understanding water management and welfare in Denmark for ethnographic tinkering and intervention. In other words, I engage with Digital Water as an ecosystem 'in which contrary forces of tension and friction, as in pulling tight, are generative of forms' (Ingold, 2017: 10).

With this dissertation, I want to provide a case for doing anthropology not only despite, but by virtue of epistemic, empirical, and disciplinary tensions encountered in the field. Anthropology has always practised 'weird' juxtapositions and strange encounters to complicate the world and provide novel ways of describing and understanding it. However, the story that I am about to tell will also show how different forms of tensions, beyond being empirical objects in the world and etic perspectives for anthropological tinkering, might also be the force that pulls different aspects of the social, as well as anthropologists and their interlocutors – collaborators, colleagues, and epistemic partners alike – together in generative ways.

In this dissertation, I explore three quite different sets of diplomatic, operational, and disciplinary tensions and show how they bring different socio-technical qualities of Digital Water to the fore. While focusing on these different tensions allows for independent and open-ended analytical tinkering with different aspects of Digital Water, altogether, they offer a case for an 'Anthropology in Tension'; a way of thinking with and enacting tensions ethnographically – whether they be disciplinary, empirical, or epistemological – and to intervene in (Digital Water) futures. In this sense, I take the tensions that form Digital Water as an analytical prism through which anthropology can engage critically, generatively, and collaboratively with its emergence.

In the concluding part of this introduction, I shall flesh out the main knowledge gaps that I cover with this dissertation and the scholarly contributions that it offers. I close this introductory chapter with an overview of this dissertation's chapters and articles.

Core Contributions

In this dissertation, I approach Digital Water through four levels of engagement, namely as 1) an empirical and discursive phenomenon which has 2) transformative material and practical implications within water management that offer 3) anthropological insights into the current state of Danish Welfare and 4) generate perspectives on ethnography as a collaborative, interventionist, and future-oriented practice in trans-disciplinary collaborations.

This dissertation engages with 'Digital Water' as a discursive and practised phenomenon that I study empirically, critically, and across multiple situations, actors, and contexts. I show how Digital Water denotes a Danish narrative of environmental stewardship through digital transformations that is centred around the creation of new speculations, innovations, and openings for the idea of Digital Water to become a commodity for international export. My ethnography complicates these ideas by showing how Digital Water emerges ethnographically as a phenomenon that takes social and material form through economic, political, sensing, and diplomatic practices. This dissertation explores not only how discourses around novel forms of digital data-based technologies crystallize within Danish water management, but also what that means in practice. It engages ethnographically with the practical implications on the ground of the idea of Digital Water to elucidate

how it materializes and becomes meaningful in the spaces where managerial, political, and economic visions meet everyday water practices and flows.

This tension, between discourse and practice within digital water paradigms, is currently underrepresented in scholarly work due to the still- (and arguably ever-) emerging nature of Digital Water. The first scientific contribution of this dissertation consists thus in providing grounded ethnographic research to a growing body of literature that is forming in the nexus between the humanities, STS, and human geography that engages critically with the discourse and politico-ethical implications of digitalizing water management (see e.g. Popartan et al., 2022; Walter, 2024). From this perspective, this dissertation traces the multiple material implications of imagining digital water at the intersection of ideas of ecological relief and economic profit in Denmark.

Water and data systems increasingly entwine in Danish water management practices because Digital Water is imagined, debated, and discussed by key industry leaders, policymakers, local government and international officials, researchers, and politicians as making up a seemingly apolitical, scalable, and rational data-based information infrastructure through interconnected, automated, and sentient devices. I refer to these actors as ‘Digital Water Pioneers’. In their view, this promises the betterment of water management and a new export endeavour for Denmark. However, as I will show, woven into the very fabric of digital water are not only the political and economic future aspirations of its main advocates. Digital water includes also concrete controversies, mismatches, and rearticulations that currently and ongoingly destabilize what it means to know, manage, and understand water flows. Building on these reflections, the second core scientific contribution that I

offer with this dissertation is located within a growing scholarship on water and data infrastructures. The socio-technical qualities and implications of infrastructured networks of data and water have been amply studied by STS, human geography, and anthropology scholars (Anand, 2017; Bowker et al., 2010; Camus & Vinck, 2019; Carse, 2012; Edwards, 2010; Jensen, 2017). However, besides a few exemplary exceptions (see e.g. Dasgupta, 2015; Irani, 2019), the relation between 'analogue' and 'digital' infrastructures, how they affect each other, become enmeshed, and how their entwining engenders radical rearticulations of socio-technical arrangements that either transform or reaffirm specific aspects of social life, is underrepresented. This dissertation aims to address this gap by offering a current and future history of (digital) water (Ballestero, 2019).

This points me towards my third mode of engagement with Digital Water. Indeed, by looking at the intersection of data and water infrastructures with commercial concerns and ideas of efficiency and optimization, I argue that engaging with Digital Water may serve as a *modus operandi* to get a glimpse into not only digital water management practices but also into the Danish Welfare. In this sense, this dissertation contributes to anthropological studies of the Danish welfare system and society (Bruun et al., 2015; 2016), and to a growing scholarship on the role of a critically engaged and interventionist anthropology of emergent technologies and potential futures (Lanzeni et al., 2023; Pink et al., 2016; Pink et al., 2022; Pink, 2022; Salazar et al., 2017), particularly as pioneered by the *EASA Future Anthropologies Network* (FAN)[2].

[2] The network was established during the 2014 EASA conference and works according to a Manifesto that can be found on their website (EASA, 2024)

Lastly, this dissertation is also an account of what it takes for anthropology to continue to make sense of – and intervene in – water management in practice, when making sense of water and acting upon it – its management, infrastructure, and future history – are altered through the digital. The final contribution of this dissertation is a reflection and intervention located at the intersection of ethnographic methods and analysis. Here, I echo the reflections of anthropologists Kim Fortun on ethnographies as being 'experimental systems' and 'machines for making the future' (Fortun, 2003: 172), and of Tim Ingold on anthropology as being not (only) a study *of*, but also *with* its interlocutors, making anthropologists researchers that 'do their thinking, talking, and writing in and with the world' (Ingold, 2011: 241-242). Both scholars, Ingold and Fortun, gesture from different angles towards an experimental, collaborative, and interventionist anthropology. These discussions have been very much alive in anthropological scholarship (Ballestero & Winthereik, 2021; Estalella & Criado, 2018; Fortun et al., 2014; Holmes & Marcus, 2008) particularly since *Anthropology as Cultural Critique* (Marcus & Fischer, 1986). With this dissertation, I contribute to this scholarly legacy by reflecting on the potential of doing an anthropology of 'Digital Water in Tension': an anthropology that reflectively stretches across critical studies *of* Digital Water, while also inherently contributing to its emergence through collaborative (and not un-critical) experimentations *with* colleagues, informants, and radically different 'epistemic partners' (Holmes & Marcus, 2008).

In sum, this dissertation attends to Digital Water in its making as a phenomenon that is nestled in discursive qualities, but which takes material form not only in innovative digital water technologies, but through a variety of more-than-human management and sensing practices, and of different

politics of future aspirations and promises. Studying this phenomenon ethnographically has posed a range of methodological and analytical challenges, but also a few opportunities for anthropology to make sense – and perhaps even intervene in the making – of (digital) water futures.

Structure of the Dissertation

The format of this dissertation is hybrid, a 'combination model'. Neither monographic nor article-based, its composite nature, it seems to me, is somehow suited for a Techno-Anthropological[3] thesis and a study *of/with* my interlocutors: water professionals and engineering colleagues in SWIft. Besides, I opted for this format because it allows me to draw on the different genres of articles, monographic writing, and to some extent ethnographic vignettes in different ways. The two articles of this dissertation afford sharper and more specific argumentation, while the 'short monograph' format engenders deeper and broader ethnographic explorations and tinkering. Tacking back and forth between scientific articles, 'monographic chapters', and ethnographic vignettes, the format of this dissertation reflects the disciplinary hybridity of my fieldwork. To this end, I have chosen to weave the two articles into the chapters of the dissertation and accompany them with an introductory empirical reflection from fieldwork.

[3] My academic background is in Anthropology and Techno-Anthropology, a degree program offered at Aalborg University. The curriculum brings social and technical insights together to develop sustainable technology and policy. I am part of the Techno-Anthropology Lab (TANTlab) at Aalborg University, a research group that works experimentally at the intersection of STS, anthropology, computational science, and humanities (TANTlab, 2024).

In Chapter 2, following this introduction, I situate Digital Water within an international and Danish context and foreground the organisational, historical, and political circumstances through which it emerges.

In Chapter 3, I unfold the theoretical framework of this dissertation. I describe how this dissertation draws inspiration and offers contributions to anthropological and STS studies of infrastructure and a futures and experimental anthropology.

In Chapter 4, I start by navigating the reader through the different phases of my fieldwork over time. Hereafter, I offer a detailed mapping of my ethnographic field according to the kinds of locations, sites, and interlocutors that populate it. I also offer a list of the ethnographic material that I have generated. Given all this, I present the methodological choices, positions, and reflections that have shaped this dissertation. I also reflect on the ethical implications of doing an engaged and interventionist, yet critical anthropology *of* and *with* Digital Water.

Chapter 5 explores how Danish narratives of ecological relief, optimization, and economic profit become embedded in Digital Water, and how Digital Water, in turn, becomes a scalable commodity through the diplomatic work of the 'Danish water ambassador'. I refer to this phenomenon as 'water diplomacy' and perceive it as an inlet to discuss how Digital Water reconfigures what it means to do diplomacy and (or as) export as two sides of the same coin in present-day Danish welfare society. This chapter is based on the first scientific article around which this dissertation is built:

Article A: Jessen, J.F. 'Water Diplomacy. Scaling Stories in Denmark and Beyond'.
Status: Submitted and in review, *Anthropological Journal of European Cultures.*

Chapter 6 attends to the tension (and junctions) between more-than-human modes of sensing, sensemaking, and knowing within digital water management. Particularly, it dwells on the relations between artificial and remote sensing systems such as water pressure and flow sensors on the one hand, and the sensing practices and situated knowledges of water utility operators, on the other. As sentient, data-driven, and data-generating models for controlling water flows increasingly penetrate water management regimes, I discuss how these technologies alter the distribution not only of sensing practices, but also of sensemaking, agency, and expertise between human and machine in digital water supply systems. This chapter also offers a rendering and reflection on the trans-disciplinary and cross-sectoral insights that were generated during the collaborative and explorative workshop: 'Human and Artificial Intelligence in Future Water Systems' that I designed and facilitated in partnership with my SWIft colleagues and four consultants from the private consultancy company 'WADE Consulting'.

In Chapter 7, I theorize on my experiences as an anthropologist in two interdisciplinary and engineering-led research projects. Here, I offer a model, or a playbook, for how to collaborate across water professionals, computer scientists, and anthropologists, but also across academia and the industry by crafting spaces for shared intellectual practice.
This chapter is based on the second scientific article of this dissertation, which I co-authored with my two supervisors, Astrid Oberborbeck Andersen

(Aalborg University) and Adrienne Mannov (Aarhus University): **Article B: Jessen, J. F., Mannov, A., & Andersen, A. O. (2023). Ideal-Real-Actual: Models for collaboration between anthropology and computational sciences.**

Status: Published, *Anthropology in Action* Volume 30: Issue 3.

With **Chapter 8**, I conclude this dissertation by reflecting on what thinking with tensions might offer to a collaborative, and future-oriented anthropology of Digital Water. I conclude with a tentative argument for studying Digital Water in Tension.

Chapter 2. Situating Digital Water A Historical, Political, and Discursive Overview

This chapter offers a glance over the emergence of Digital Water in Denmark. To begin with, it elucidates how the premises for Digital Water to take root in Danish water management stem from global imaginaries and discourses of (economic, humanitarian, and ecological) crisis and relief through digital solutions. It then shows how these perceptions become discursively rooted in ideas of efficiency and optimization pioneered by leading actors in the Danish water sector, practically embedded in national water management strategies and economic roadmaps and finally, how they materialize in altered organisational practices.

Digital Water Between Crisis and Relief

Pressed by challenges of either water scarcity, too much water, increasing amounts of dirty and untreated water, ageing infrastructure, and increasing urbanization, the management of global water flows is widely regarded to become increasingly unsustainable in the coming years from a humanitarian, economic, and environmental perspective (UNESCO, 2021). In fact, water authorities and scholars alike perceive water-related challenges as some of the biggest threats to global livelihoods and economies (Cosgrove & Rijsberman, 2000; Hastrup, K. & Hastrup, 2015b; Strang, 2021).

Within the context of a widespread sense of crisis impending on global waterscapes, the International Water Association (IWA), one of the main global interest organisations that promotes innovative solutions for water and

wastewater management, has begun urging an increased development and integration of digital data-based and semi-automated technologies within traditional water supply systems. These technologies include, but are not limited to, remote sensing technologies, smart metering and pressure management solutions, satellite imaging, virtual reality, automated pump controls, and data-driven leakage detection systems. Altogether, as mentioned in the introduction, these water technologies, in synergy with global water infrastructure and technology companies, academic institutions, innovation hubs, and the public sector, are imagined by the IWA to create an 'ecosystem for Digital Water' (IWA, 2019: 14).

With its global headquarters located in London, United Kingdom, the IWA is a self-governing nonprofit organisation that functions as a global network and knowledge hub for all kinds of water professionals and experts. Hosting a broad range of peer-reviewed journals and global flagship conferences for water professionals such as the World Water Congress & Exhibition (WWCE), the IWA is the largest international membership association for water professionals, bringing stakeholders from over 140 countries (IWA, 2024c). As such, the IWA has a substantial voice in the international water industry, research, and policy. Through a range of task groups, communities, and specialist clusters, the IWA covers all stages of the water cycle from research to practice to 'provide innovative solutions to the serious water challenges facing the world today, as well as nurturing the next generation of water leaders through its young professional's programme' (IWA, 2022a). Through these communities, the IWA sets 'change agendas' on 'key themes for a water-wise world that can contribute to sustainable development' (IWA, 2024a). One of these agendas is the 'Digital Water Programme', which offers a platform for IWA members to explore Digital Water through a series of

white papers, blogs, podcasts, and forums where they can share experiences on 'their digital water journey'. Hereby, the IWA claims to 'provide roadmaps and guidance that will help water utilities in making the transition to the next generation of smart water systems and fulfil the need for improved resiliency to secure and sustainably manage water resources now and in the future' (IWA, 2024b). As such, the discourse underpinning Digital Water as authored by the IWA, revolves around two central claims.

Firstly, portrayed by the IWA as a 'paradigm shift to the next generation of water systems beyond traditional water and sewerage infrastructure' (IWA, 2024b), Digital Water is seen to be made up of a variety of digital tools that altogether promise a (variety of) solution(s) to withstand the significant pressure inflicted on water networks by what the IWA refers to as 'the great water challenges of our time, namely climate change, population growth and ageing infrastructure' (IWA, 2024b). Secondly, as the vision goes, the Digital Water agenda takes form as an economic asset for 'the global water sector' by 'exploiting the value of data, automation, and artificial intelligence' (IWA, 2019: 8). In other words, the discourse around Digital Water is strung out between entwined promises of ecological relief and economic profit which are held together by the idea of 'smartness'.

Influencing how digital water technologies are discussed on a strategic, academic, and political level internationally and locally, the IWA sets, to a large extent, the digitalization of water management on the agenda of water utility companies and national governments as a form of water crisis relief policy. As a result, IWA's visions and expectations of Digital Water affect political debates and negotiations, industrial pathways, and economic strategies for the present and future of water management on an international

scale. As Theodora Dryer reports at length in a North American context, however, digitalization and innovation initiatives primarily serve the technological innovation and economic agendas of data-rich and digitally mature countries (Dryer, 2022). This is also the case in Denmark, where political and state apparatuses as well as research agendas increasingly engage with notions of 'smart' and with digitalization processes within water management.

Smart Water Infrastructures

The management of water and its infrastructure has always been carried out in distributed forms, that is, in networks where human expertise and skills collaborate with a variety of artefacts and technologies to know, control, and distribute water. And information about water – availability, demand, flow, usage, etc. – has been crucial for securing water supply for as long as humans have built infrastructures for water distribution. Human relations to water, one might say, have long been mediated by technologies and information. With the uptake of digital water technologies, these forms of information are increasingly taking form as digital data, and the sensing bodies through which such information is created are increasingly artificial (Popartan et al., 2022). This integration of algorithmic systems within traditional water infrastructures is often referred to as a process of 'smartification'.

Within water management and in the SWIft project – the interdisciplinary Aalborg University research project to which this Ph.D. forms an ethnographic contribution – 'smart' is an idiom that points at the capacity associated with cyber-physical systems to 'optimize' water flows through automated digital data-driven technologies and algorithms. As Michael Fischer (2018) phrases it, smartness is defined by the degree to which devices

and infrastructures are ‘responsive, able to pass information from one place, or state, to another’ (Fischer, 2018: 350). In turn, optimization is arguably seen by my engineering colleagues in SWIft as a fundamentally quantitative operation that is sought out mathematically through data-driven methods such as multi-objective programming and Artificial Intelligence (AI). These methods are aimed at finding e.g. the minimal energy necessary to run specific water operations, the most cost-effective way of locating leakages in water networks, the most reliable prediction of how long water infrastructure will last before breaking, as well as improving the robustness of Digital Water solutions against system faults and cyber-attacks (Misra et al., 2022; Misra et al., 2023; Saruch et al., 2022). In short, the pursuit of ‘best’ is what justifies smartness (Halpern et al., 2017: 118). As such, smartness appears to justify increasing demands for new and better sensors, sites of data collection, and algorithmic models to provide an ever-more solid and arguably objective digital data-based foundation for decision-making within water supply management through algorithmic parsing and processing.

This understanding of ‘smart’ somewhat resembles what Orit Halpern, Robert Mitchell, and Bernard Dionysius Geoghegan (2017) refer to as the *smartness mandate* in the context of the 2008 rise of so-called ‘smart’ technologies and ‘internet of things’ within the computing technology business. Their notion of the history and logic of smartness inspires my second engagement with notions of smart, which stands in tension with the former, rather techno-optimistic and positivistic approach of my colleagues in SWIft. It is this rather critical approach to ‘smart’ that inspires my ethnographic contribution to the SWIft project. Drawing from a speech of the former chairman of IBM, Sam Palmisano in the aftermath of the 2008 economic crisis, Halpern et al. emphasize how current invocations of smartness build on the idea that a

perpetual optimization and adaptation of computational technologies will produce 'a more resilient human species – that is, a species able to absorb and survive environmental, economic, and security crises' (Halpern et al., 2017: 107). This future vision, despite emerging from 'engineering thinking', they continue, currently infuses 'regional and transnational strategies of governance', encouraging the 'creation of novel infrastructures that organise environmental and energy policy, supply chains, the distribution of food and medicine, finance, and security policies' (ibid. 109-110). These processes, they posit, present smartness as 'a self-regulating process of "optimization" and "resilience"' (ibid. 110) that assumes states of climatic, financial, or security crises as being imbued with an aura of opportunity for perpetual growth by distributing and decentralizing agency and intelligence 'among objects, networks, and life forms' (ibid. 108). Accordingly, the insights brought by digital data-driven and smart technologies within water management are imagined by the main advocates of Digital Water, including my SWIft colleagues, to significantly augment the 'factuality' of the information that leads to actions and investments in the water management system. Actions, which are arguably otherwise ofttimes taken based on increasingly unreliable human memory, *a posteriori* insights, and 'gut feelings'. I return to review and discuss the relationship between what Digital Water pioneers refer to as 'gut feelings', human experience, and intuition on the one hand, and 'hard', 'factual', and data-based predictions on the other in present-day Danish water management practices in Chapter 6.

In what follows, I recalibrate our scale of attention to discuss how Digital Water, and the ideas of 'smartification' and 'optimization' that it entails, travel from global aspirations promoted by the IWA to Denmark and become anchored in Danish water research and management strategies as aspirations

of ecological relief and market expansion. In moving from a global to a local scale, I continue by showing how the Digital Water discourse has discrete, albeit entangled material and performative implications.

Digital Water made in Denmark

As of the latest public calculations, the Danish water sector consists of some 2.600 waterworks and 701 wastewater treatment plants. Altogether they distribute approximately 310 million m^3 of drinking water and treat about 95 % of the total wastewater produced in the country (DANVA, 2022: 10-11). For more than 20 years, the Danish water sector has had water loss reduction and energy neutrality among its primary political matters of concern. Water loss refers to drinking water that is treated and pumped into the pipeline grid, but which does not reach water utility customers due to either ruptures and leaks in the water network or unauthorised consumption. Such lost or unaccounted-for drinking water is seen as a waste not only of a primary resource, but also of the economic and energetic resources used to extract it, treat it, distribute it, and of the lost revenue for water utility companies. Lost water is therefore also known as Non-Revenue Water (NRW). Energy neutrality refers, instead, to the amount of energy used to treat wastewater. Wastewater treatment is an energy-intensive process that operates twenty-four-seven to pump water through the sewers and for the process of rinsing sludge at wastewater treatment plants. Reducing NRW and improving energy efficiency are thus a matter of reducing economic costs and the environmental impact of water management. However, water loss reduction and energy efficiency are also perceived politically in Denmark as modes of staging Danish excellence within water management for export purposes. In a sense,

digitalization has played a central role in water management practices and the international 'branding' of the Danish water sector for decades already.

Denmark is often referred to as a frontrunner in water technology development in terms of economic efficiency, water loss, and sustainability (DANVA, 2022; The Danish Government, 2021). Whether IWA's and, by extension, the Danish government's emphasis on the digital as a new paradigm for water management marks a significant shift 'to the next generation of water systems' (IWA, 2019) as opposed to a continuation of something that has been happening for decades is debatable. As is the case for other kinds of environmental data (Gabrys, 2016), the management of water flows at most Danish water utility companies already encompasses networked water sensor data that are increasingly integrated with traditional water management systems. These water data are conglomerated, made legible, and actionable to water utility employees through monitoring, surveillance, and data visualization software supplied by industrial IT companies called SCADA (Supervisory Control and Data Acquisition). SCADA systems have played a central role in Danish water management regimes for decades, augmenting and automating many aspects of the control of water flows, consumption, pressure, and distribution. Through SCADA systems, Danish water management entails the management of flows of digital water data through electronic systems parallel to the water flowing through the pipes. The latest development in SCADA systems is to introduce Artificial Intelligence (AI) and automation of processes. These innovations are largely claimed to move the technology from *monitoring* water systems towards the *prediction* and *anticipation* of future water flows. Today, SCADA systems are mainly used to automatically synchronize water pumping systems to stay within given limits in order to ensure a continuous

flow and stable pressure throughout the system despite varying consumption patterns. Furthermore, the graphic user interface allows operators at the water utility to monitor the proper functioning of the system for eventual faults and flaws.

Among Danish water professionals, the rise of these technologies is often related to the introduction of a set of regulations and reforms for the aquatic environments introduced by the Danish Environmental Protection Agency in the late 1980s (DANVA, 2022). Beginning with the 1987 'Action Plan against Pollution with Nutrients of the Danish Aquatic Environment', Denmark was an early adopter of environmental and climate policy measures, including binding regulations aimed at reducing the discharge of pollutants from industrial and household wastewater. Other often-mentioned examples are the 'Water Tax Act' (1993) and the Danish 'Water Sector Reform Act' (2009). With the former, Denmark became the first country in the world to impose a penalty for drinking water utility companies with water losses above 10% in the public drinking water network and a tax on tap water of DKK 5 for each m^3 of water (€0.63/ m^3). The latter was fostered by the former ruling government's (2007-2009) New Public Management-inspired policy on privatization and optimization of public institutions (Staunstrup et al., 2023: 14). The Act cements the separation of municipal water and wastewater supply activities from the local municipality, transforming them into quasi-private non-profit public limited companies with access to capital markets and a managing director, but whose shares are owned by the local municipality. Finally, it introduces the so-called 'break-even' principle. This means that while Danish water utility companies are 100% financed through tariffs paid by their customers, they are allowed, in addition to their water and wastewater activities, to sell services, residues, and energy with a certain profit provided

that these activities are closely linked to their drinking water and/or wastewater activities. In addition, the Danish water sector is subject to efficiency requirements, which compels water utility companies to reduce their revenue framework from customer tariffs annually. These requirements are formulated as an incentive to reduce operating costs over time (in terms of energy efficiency and water losses) because there will be less revenue to cover those expenses, but also as an incentive for water utility companies to invest in better and more efficient water technologies (DANVA, 2022: 12). As such, these initiatives are seen as measures to create conditions like those on competitive markets in an otherwise monopolistic environment and 'to prevent socio-economic waste and stimulate development, innovation and climate-friendly energy production' (ibid. 10).

Over the years, these reforms have provided regulatory, legislative and, with the break-even principle, increasingly neoliberal, competitive, and market-oriented stimuli for Danish water utility companies and other key stakeholders in the Danish water sector to invest in new technologies (Pedersen, O. K., 2011). This orientation of the Danish water sector has become even more apparent in lately published 'sector development reports' and strategies (CALL Copenhagen, 2018; Mikkelsen et al., 2019; The Danish Government, 2021).

Strategizing Digital Water

'Let water and data flow' is the title of a so-called Danish sector development report published in 2019 (Mikkelsen et al., 2019). As its main title, the report's subheading is also rich in metaphors (and interests) that somehow converge towards ideas of mastery, liberty, and progress: 'The Danish water sector stands in front of a choice. To surf the digital wave. Or to be flooded

by it' (ibid. 1). The report was published by the Danish Technical University (DTU) in collaboration with FRI, the Danish Association of Consulting Engineers, and the Confederation of Danish Industry (DI). It maps out the potential, in terms of improved system efficiency and environmental benefits, of adopting smart and digital technologies for water management. Further, it outlines pathways for economic profit and development through the export and scalability of Danish water technologies and suggests that they may be used to solve all kinds of water challenges and crises worldwide. The message of the report is clear: open and interoperable flows of digital data *will* ensure that the Danish water sector 'surfs the digital wave' instead of being flooded by it.

Written to accelerate the development of new water technologies and solutions for water management, the report offers a roadmap for Danish policymakers and water professionals to operationalize and capitalize upon Digital Water. It postulates five recommendations for a successful digitalization of water management. Interestingly, rather than focusing on the technologies *per se* or actual challenges of water management in Denmark, these recommendations are centred around strengthening the 'ecosystem for water technology' to improve its capabilities to innovate and to compete in the international market for water technologies. In other words, the report engages a commercial terminology, indicating that it is devised to influence policymaking within the Danish water sector towards increasing export. Asking for a 'shared vision and set of incentives' for digitalizing the Danish water sector (Mikkelsen et al., 2019: 7), the recommendations revolve around addressing how a more liberal, less regulated, and more internationally oriented political approach would benefit the Danish sector. These involve creating the legal and political conditions that afford diverse stakeholders to

share, instead of withholding, digital water data amongst each other and by offering better conditions for startups and innovation hubs within the Danish water industry (ibid. 57-60).

The report was published as part of a campaign led by DTU and other stakeholders, including DI and the national association of Danish water and wastewater utilities, DANVA, in the wake of the latest IWA WWCE to attract the Congress to Denmark under the theme 'Water for Smart Liveable Cities'. Eventually, the event was convened on September 11–15 2022[4] in Copenhagen and welcomed 8.900 water professionals and companies from around the world. In line with the discourse around Digital Water, the main theme of the event was to 'explore smart, holistic, and liveable city solutions that utilize synergies between various intelligent systems, empower cities to adapt to a changing climate and meet the Paris agenda, whilst improving the quality of life and well-being of our societies'. The vision was portrayed as being achievable through the development of 'a global culture of innovation that can enable the radical transformations required' (IWA, 2022b). On a national political level, these 'radical transformations' towards an innovation culture in water management were arguably already set in motion.

In 2020, the Danish Ministry of Foreign Affairs published an Export Strategy for Water in collaboration with the Danish Ministry of Industry, Business and Financial Affairs, and the Ministry of Environment of Denmark (The Danish Government, 2021). The strategy outlines pathways to national economic development through the export and scaling of Danish water technologies. Aligned with the visions of the international water milieu (IWA, 2019; Krause

[4] The congress was originally scheduled for 2020 but was postponed to 2022 due to the outbreak of the COVID-19 pandemic.

et al., 2017), these technologies are imagined as promising solutions to deal with 'some of the world's largest global challenges', namely 'lack of clean drinking water, untreated wastewater, drought, and floods' (The Danish Government, 2021: 4). As the strategy's narrative goes, Denmark holds a leading position 'to provide intelligent and sustainable solutions' for an increasing global demand' (ibid.). The ambition is very concrete: for the Danish water sector to contribute to solving the world's water and climate adaptation problems 'through a doubling of Danish water technology exports from DKK 20 billion in 2019 to DKK 40 billion in 2030' (ibid. 10).

Notably, what is at stake in the two reports is not necessarily improving *water management* in terms of offering improved services for local well-being in Denmark. It is, rather, to strengthen the position of the *Danish water sector* as an economic institution and industry. They do this by creating new speculations and conditions for the betterment of water technologies, the export of which, it is suggested, will help sustain the costs of Danish Welfare while also sustaining its increasing ambitions of economic expansion. As these reports show, the connection between ecological and humanitarian relief, ideas of smartness and optimization, and economic profit in Danish (digital) water politics, is striking. Danish 'smart' water solutions have come to marry ideas of environmental stewardship with the idea of creating more efficient water management for commercial purposes by means of long-lasting political and regulatory work. As such, one might say that Digital Water is the result of infrastructural work that, while springing out of environmental concerns, holds the promise not only of more precise asset management, forecasting, and prediction within water utility services. It aims also, and perhaps primarily, at constructing a discursive and commercial

framework that might allow Digital Water to sustain the expansion of the Danish national economy.

In the next pages, I tease out how the political and strategic incentives and aspirations that are embedded in Digital Water become materially and performatively manifest in practice. I do so by presenting four exemplary material and performative manifestations of Digital Water in Denmark. These include the establishment of novel water innovation centres and alliances and the work of scaling Danish water solutions internationally through export and diplomatic practices through the figure of the 'Danish water ambassador'. Through these empirical cases, I aim to portray what it means in practice for the solutions that shape Danish water futures that digital water discourses point toward entwined ideas of ecological relief and economic profit.

A Business Lighthouse for Water Technology

In 2022, the Danish Ministry of Industry, Business, and Financial Affairs established a consortium aimed at creating a Danish 'business lighthouse for water technology'. Bringing together companies, water utilities, knowledge institutions, and municipalities across the country to 'promote the green transition, combat climate risks, and harness the potential in the development of Danish water technology and solutions' (The Danish Ministry of Industry, Business, and Financial Affairs, 2024). The initiative is built around two innovation platforms within the Danish water sector: 'Water Valley Denmark' and 'Klimatorium'.

Water Valley Denmark – a name with strong associations to Silicon Valley in California – is the latest organisational infrastructure for the exhibition and development of cutting-edge Danish water technology. Based in Aarhus, a

series of key actors within the Danish water sector are a part of this alliance, which has as its vision to 'accelerate global green growth by establishing one of the world's strongest platforms for water innovation' and setting up a physical innovation district that will function as an epicentre for knowledge, development, and demonstration of Danish water solutions (Water Valley Denmark, 2024a). Similarly, Klimatorium, or 'Denmark's international climate centre' (Klimatorium, 2024) is a water research institution owned by Lemvig Water. It acts, in accordance with one of the paragraphs of the Danish Water Sector Reform Act, as a platform that 'supports innovative development and demonstration and export of Danish water technologies' (Water Sector Reform Act, 2009: §1). According to the CEO of Lemvig Water, Klimatorium is a place where real-world water-related problems and challenges are approached through collaborative efforts between local and international private companies and universities to find innovative solutions to the manifold consequences of rapidly changing environmental and political climates.

Through Klimatorium and Water Valley Denmark, the Danish water sector has initiated a handful of digital innovation projects and launched several startup companies within water technology. These include but are not limited to the prototyping of a 'water data space': a digital platform for the sharing and co-production of water supply data across different actors and stakeholders (Water Valley Denmark, 2024b), and the use of satellite data to capture and predict local ground subsidence in relation to the operation and maintenance of underground infrastructure[5] (DANVA, 2020; Sorensen et al.,

[5] Lemvig Municipality is affected by extreme local ground subsidence rates of up to several millimetres of yearly terrain level changes in the area around the town of Thyborøn. These ground movements threaten to disrupt the utility's underground infrastructure, which is worth

2016). Another concrete business outcome of Digital Water is the Danish startup company 'TopData'. TopData offers a cloud-based subscription software solution for water infrastructure and asset management for water utility companies. By integrating datasets gathered from different sources, such as SCADA systems, weather data, GIS data, and different public data sources, TopData claims to provide a platform that uses generative AI and machine learning technology to offer 'objective' and 'fact-based' guidance for costly reinvestments in water infrastructure, which are otherwise taken, they claim, based on often-faulty human 'gut feelings'. I will dwell on the relationship between human 'gut feelings' and the claimed 'objectivity' of data-driven decision-making software in these kinds of digital water solutions in Chapter 6.

For now, let me simply emphasize how these are but three out of many ways in which Digital Water becomes materially embedded in novel water solutions and physical innovation hubs in Denmark. They hold the promise not only to regain control over increasingly unruly watery environments but also to offer new pathways for economic expansion. Furthermore, innovation centres such as Water Valley Denmark and Klimatorium, as we have seen, also promise to spread Danish water solutions globally. They serve, in other words, as platforms where Danish water solutions are developed not necessarily for the solving of local challenges, but rather to be staged and showcased for their scaling and global export. This process of scaling is

DKK 1.2 billion (€ 161 million). Lemvig Water uses satellite data to estimate the magnitude and pace of future local ground subsidence to adjust their hydraulic modelling accordingly and thus extend the lifetime of their water infrastructure.

performed in practice through the last materialization of Digital Water that I wish to present here, namely the 'Water Technology Advisory'.

The Water Technology Advisory

The Water Technology Advisory (WTA) was established in 2014 in Chicago as a Danish outreach program providing 'specialized know-how on innovative water technology solutions' that could foster novel trade collaborations between the North American and Danish water sector (Ministry of Foreign Affairs of Denmark, 2024). The initiative is formally administrated by the Ministry of Foreign Affairs of Denmark, and its partners include a handful of the biggest public Danish water utility companies, the Danish Environmental Protection Agency, and leading technology and service providers. Since its inception, the WTA has proved to be successful in strengthening the bond between the Danish and North American water sectors and helping Danish water technology providers access the North American market, which until then had been hard to enter. In 2021, during the COVID-19 pandemic and in the immediate aftermath of the publishing of the Danish export strategy for water, the initiative was launched by the Danish Ministry of Foreign Affairs in Europe too (WTA EU). With support from the EU post-pandemic Covid-19 recovery funds (European Commission, 2024), the WTA EU has the overt aim of contributing to the political ambition of the Danish government to double the turnover from the export of water technologies by 2030 (The Danish Government, 2021). The WTA EU has as its aim to expand the Danish market for water technology by influencing other European countries to invest in Danish technical water solutions. Thus, the WTA EU has selected five prioritized 'export markets' that are expected to

invest most heavily in renewing and improving their water infrastructures: Germany, Italy, Poland, Portugal, and Spain.

This work of market expansion through knowledge sharing and dissemination is practically performed by a so-called 'sector expert' who is also often informally addressed as a 'water ambassador'. The Danish water ambassador is an expert in water management with concrete experience from the Danish water sector, who collaborates closely with a 'local expert' with extensive knowledge about local waterscapes, customs, and socio-political circumstances. Through the role of the Danish water ambassador and the local expert, the WTA establishes what it refers to as a 'soft sell' approach, or 'knowledge exchange' between Danish and local water utilities with the silent ambition of facilitating the access of Danish water companies to new potential international markets.

According to the Danish Export Strategy for Water, Italy is one the most promising upcoming 'markets' for water technology, as it is expected to be one of the European countries to invest most heavily in its water supply systems over the coming years. For this reason, as part of my fieldwork, I have followed the work of the Danish water ambassador at the Royal Danish Embassy in Rome to get a glimpse into how Digital Water extends beyond local practices and ideas in being politically imagined and strategically performed by its main advocates as a catalyst for economic growth and market expansion altogether (see Chapter 5). In practice, the Danish water ambassador in Italy has visited over 70 Italian public water utilities between 2021 and 2023 to assess their potentials and challenges to 'match Danish competence where it fits', as he phrases it. Beyond that, he participated in organising a range of workshops, seminars, and delegation visits, where

representants from Italian water utilities with the biggest potential and interest in Danish solutions were invited to Denmark on dedicated 'fact-finding trips' to see and experience Danish water solutions in practice at Danish water utilities. Instead of inviting Danish companies to try to sell their technologies as part of a solution, one of the key approaches of the ambassador is to engage leading Danish water utilities in sharing – or, as I will argue, in selling – the story behind their solutions to water-related challenges. These stories are centred around the pilot projects and cutting-edge technologies developed by institutions such as Klimatorium and Water Valley Denmark and showcased at specific Danish water utilities to legitimize the quality of Danish products in the eyes of potential new customers. I further explore this phenomenon as a form of *water diplomacy* and its relation to ideas of competition, export, and international relations in the Danish Welfare State in Chapter 5.

Wrapping up: Promising Smartness for Profit

In this chapter, I have sketched the historical, political, and discursive background of Digital Water. I have also discussed how particular perceptions of 'smartness' and digitalization as optimization, ecological relief, and economic profit have become embedded into Danish water management aspirations and practices, and how these are articulated and manifested in ways that allow them to propagate over time and space. As we have seen, Digital Water emerges as a promising field for problem-solving and economic growth among different actors – water professionals in the global scene and in the Danish water sector. Digital Water is imagined, materialized, and performed by its main advocates – Digital Water pioneers – as an enabler not only for real-time and interoperable water data to provide 'solid' ground for informed decision-making in an ever-more uncertain and

shifting world but also as a catalyst for economic growth and market expansion. These actors have in common that they envision water systems to become close-to perfectly efficient through their digitization and automation, and that smart water technologies will become a new resource frontier that ignites economic growth while unlocking a variety of promising solutions for the local and global water challenges.

As such, Digital Water is envisioned by leading industry stakeholders and utilities to carry a lot of promise (Anand et al., 2018). A promise that takes on local and national forms, but that is global in its aspirations. It is a promise of optimization and access, of equitable water futures, and of responding to current and future climatic challenges. And, for the most inventive, it is also a promise of new international export enterprises (Andersen, Astrid Oberborbeck & Jessen, 2023). In the next chapter, I proceed by situating this dissertation in a theoretical and scholarly framework at the intersection between infrastructural studies in anthropology and STS and a futures anthropology.

Chapter 3. Digital Water in Theory

With this chapter, I offer a glance over the analytical field of inquiry within which I position this dissertation. This study is primarily anchored – and provides scholarly contributions to – infrastructural studies in anthropology and STS (Anand et al., 2018; Bowker & Star, 1999; Harvey et al., 2016; Larkin, 2013; Star & Ruhleder, 1996; Star & Bowker, 2002) and to an emergent futures anthropology (Lanzeni et al., 2023; Pink et al., 2016; Pink et al., 2022; Salazar et al., 2017). It also provides a scholarly contribution to ethnographic studies at the intersection of water management (Anand, 2017; Jensen, 2017) and digital infrastructures (Bowker et al., 2010; Edwards, 2010), but also of the Danish Welfare State (Bruun et al., 2015; 2016). It also engages ethnographic literature on processes of market expansion, scaling, and scalability within contemporary capitalist societies (Appel, 2012; Tsing, 2005; Tsing, 2012). Positioning myself thus, this chapter will segue into my methodological and analytical approach to fieldwork and Digital Water.

Infrastructures in Anthropology and STS

> *New digital technologies are enabling water utilities and industries across the world to extract greater information and efficiencies from legacy water infrastructure to enhance decision-making, promote water conservation, build twenty-first century water infrastructure, and – perhaps most importantly – increase the value and benefits of the global water infrastructure network. […] Welcome to the future of water.*
>
> (Krause et al., 2017: 4-5)

The opening quote of this chapter originates from an industrial white paper on 'The Digitization of Water. Intelligent Water Platforms for Water Abundance' (Krause et al., 2017). It emphasizes how digital water technologies are imagined to be built on top of existing water infrastructure to better its qualities. With a legacy stemming from nineteenth-century French civil engineering and military operations, infrastructure is popularly considered a collective term that designates a plurality of permanent installations such as airports, roads, ports, and piping systems that *support* other projects (Carse, 2017; Oxford English Dictionary, 2024). As indicated by the prefix *infra* – meaning beneath, below, or within – infrastructures suggest some sort of relationship of depth and hierarchy (Carse, 2017). This implies that infrastructures have 'conventionally been viewed as material substrates underlying social action' (Jensen & Morita, 2017: 1).

Many ethnographic studies of infrastructure have focused on how infrastructures give material form, and thereby undergird relations of power, (often neoliberal) political projects, and hierarchies between different actors in particular contexts – and render them ethnographically accessible (Appel, 2019; Fortun, 2004; Harvey & Knox, 2015; Leivestad & Markkula, 2021; Starosielski, 2015; von Schnitzler, 2008). In so doing, the anthropology of infrastructure travels a path paved by earlier STS explorations of infrastructure (Jensen & Morita, 2017: 4). These studies were originally centred around large technological and ICT systems (Bowker & Star, 1999; Edwards, 2010; Hughes, 1993; Latour, 1996). In recent years, however, a proliferation of scholarly work has blossomed around a range of other fields, including, but not limited to, energy (Abram, 2022; Watts, 2019), roads (Harvey & Knox, 2015), global capitalism and logistics (Appel, 2019; Leivestad & Markkula, 2021; Starosielski, 2015; Tsing, 2005), and cyber-

physical systems (boyd & Crawford, 2012; Hogan, 2015; Selbst et al., 2019). These scholars regard infrastructures as focal loci to study the socio-materiality of political and social change ethnographically in a way that refuses to separate the technical, material, and logistical from the human and cultural.

From this perspective, the developments within the digitalization of water management in Denmark can be seen as a window to study not only Digital Water but also the political desires and efforts invested in making (digital) water solutions scalable and profitable. This is particularly apparent in how Danish utility companies – through institutions such as Klimatorium in Lemvig – are increasingly designed not only to supply drinking water and handle wastewater efficiently, but also to 'develop and showcase Danish water solutions to the world for export', as emphasized by one of my interlocutors, a water professional at the Confederation of Danish Industry, Denmark's largest business and employer's organization (see also The Danish Government, 2021).

I want to bring attention to a key and influential conceptualization of infrastructure, which was first developed in STS studies by Susan Leigh Star and Karen Ruhleder (1996). They define infrastructure in terms not only of heterogeneous and layered technologies, but also of organizational and social arrangements that embody certain standards, classifications, habits, norms, and routines. Star and Ruhleder remind us that 'infrastructure is a fundamentally relational concept. It becomes infrastructure in relation to organized practices' (Star & Ruhleder, 1996: 113). As Brian Larkin phrases it, infrastructures are at once 'things' – 'objects that create the grounds on which other objects operate' – 'and also the relation between things' (Larkin,

2013: 329). For one thing, as Casper Bruun Jensen and Atsuro Morita frame it, this means that 'infrastructures organize flows of materials and create relations between the dispersed practices and activities connected to such flows' (Jensen & Morita, 2017: 4). Water infrastructures connect the utility operator's leakage detection practices with the homeowners' dishwashing practices, with microbial life, and chemical residues through water flows. For another, infrastructures 'mediate between those for whom infrastructures are typically *foregrounded* and those for whom they tend to be *backgrounded*' (ibid. 4-5). Algorithmic systems are usually background for the water utility employees that use SCADA systems but foregrounded by the data scientists that coded them. Understanding infrastructures as relational, as these scholars do, means that changes in infrastructural relations become central to the study of infrastructure. This has also been referred to as the 'double relationality' of infrastructure (Harvey et al., 2016). Infrastructures emerge, in other words, for people in practice, as large-scale solutions that enable local activities.

In the field of Digital Water, we see how the uptake of interconnected and 'smart' sensing devices along water catchment areas and piping systems are imagined connecting new promises of resource sustainability, infrastructure management, and profitability to water management among water professionals. We also see how these connections allow for novel flows of data and information among artificial sensing devices and water utility actors and vice versa. But we also see how smart water technologies and solutions, and the ideas embedded within them, elicit, uphold, and infrastructure new relations and exchanges between computer scientists, political actors, and commercial actors which, in turn, e.g. form new international diplomatic and commercial practices that allow Digital Water to become scalable and

profitable (see Chapter 5). It is with these studies in mind that I approach Digital Water as infrastructure.

Water and Data (as) Infrastructures: Toward Digital Water

As part of the 'infrastructural turn' in anthropology and STS beginning approximately at the turn of this millennium, scholars have shown interest in studying water (supply) and watery environments as points of departure to understand social and political processes (Anand, 2011; 2017; Carse, 2012; Hastrup, K. & Hastrup, 2015b; Jensen & Morita, 2020; Orlove & Caton, 2010). As a finite resource managed and governed in relatively closed systems, knowledges, and practices of managing water flows have developed over millennia in different parts of the world. The ancient civilizations of Egypt, Rome, and China, amongst others, were built around the control of the water of great rivers, testifying to the intimate relation between planned water control and social patterns of governance. For anthropologist Veronica Strang (2004), water has been 'a metaphor of social, economic and political relationships – a barometer of the extent to which identity, power and resources are shared' (Strang, 2004: 21) since the rise of the first complex agricultural societies. From this viewpoint, as a 'dynamic partner in navigational and social opportunities and setbacks' (Hastrup, K. & Hastrup, 2015a: 11) – as a connector – water itself 'can be seen as a social infrastructure or technology, since it channels and shapes social practices and relations. Water, in a sense, distributes particular forms of social organisation, labour, politics, and technological efforts, thus arranging and structuring activities around it' (Andersen, Astrid Oberborbeck, 2022: 722). With the increasing adoption of digital sensors in water management, one might add that water distributes a particular kind of information too. One that takes form

as numbers and digits, digital datasets of real-time water flow, pressure, and of its biological composition at a certain time and place, but also of potential water futures.

Accordingly, ethnographic accounts of data and data infrastructures demonstrate the many ways in which 'social worlds are entangled with data that is produced, circulated, and analysed using computational devices' (Knox & Nafus, 2018: 1). These studies show how data (systems) can be 'broken' (Pink et al., 2018b), how they form and inform practices and 'moments' (Douglas-Jones et al., 2021; Maguire et al., 2020), and algorithmically enacted *as* culture (Seaver, 2017). Data can be 'raw', 'cooked' (Gitelman, 2013), 'rotted', and 'thick' (Boellstorff, 2015). Data allow for novel forms of digital and 'intelligent' sensing practices that make up a 'computational planet' (Gabrys, 2016) and 'informated' environments (Fortun, 2004). In contrast to water flows, (big) data flows have a recent and quickly developing history and hype (Boellstorff, 2015) in popular and industrial imaginaries. They are cumulative, immeasurable, and virtually infinite (Hogan, 2015). Just as water, however, data is relational too. Tom Boellstorff and Bill Maurer (2015) emphasize how 'data is formed through relations that extend beyond "data" itself; how what counts as data (and data's referent) is a social process with political overtones; and that data is always in real-time transformation in ways that cut across notions of nature and culture' (Boellstorff & Maurer, 2015: 3-4).

Ethnographic studies of water and data teach us that the circumstances around infrastructures matter. It matters how the infrastructures channelling these circumstances are constituted because it helps us see the transformations in social life that they in turn engender. However, water and data studies have

other commonalities. Firstly, they consider how water and data provide an ethnographic inlet to studying local and global power relations and cultural transformation. Secondly, they also stress the ability of water and data infrastructures not only to 'mirror social relations, but also to reconfigure them in the same way as they reconfigure natural environments' (Jensen & Morita, 2017: 4). In this sense, seeing them as infrastructure emphasizes how data and water are not just *formed by*, but also *give form to* culture, society, and politics.

While ethnographic studies of infrastructure offer nuanced and strong analytic approaches to the materiality, discourse, and imaginaries around water and data, a perspective on the practical implications of their entwinement in smart water infrastructures is still to be explored. Studying digital water infrastructures means tacking back and forth between two diverse and layered infrastructures: 1) The network of built and closed systems of pipes, knowledges, practices, risks, and the global water and market flows that comprise the infrastructure of water management; and 2) the open systems of cumulative, immeasurable, and infinite flows of data, know-how and expertise, as well as innovation strategies, sustainable agendas, control and risk protocols and machine ensembles that comprise contemporary digital infrastructures. As infrastructures of water and data become increasingly interwoven, the emergence of Digital Water and its impact on water economies, water justice, and power, points at how these kinds of studies seem to be ever-more needed. Following Andersen (2022), as water flows are increasingly controlled and optimized through data flows, and water supply systems become inhabited by smart metres, remote sensing technologies, and algorithms, it becomes pressing to ask what happens when data infrastructures and water infrastructures entangle (Andersen, Astrid

Oberborbeck, 2022: 735). What kinds of social, political, and economic relations does Digital Water engender? How do we conceptualize Digital Water as a form of infrastructure of 'water-cum-data', for lack of better words? How do we make ethnographic and conceptual sense of entwined water and data infrastructures? The next pages are an attempt to offer one such theoretical perspective grounded in a futures and interventionist anthropology.

Infrastructures and Futures

While 'Digital Water pioneers' – the main proponents of the uptake of smart and digital water solutions within water management systems – claim that Digital Water is 'already here' on a strategic level, it is not in practice. Rather than being 'here', Digital Water is inherently 'in progress, ongoingly emergent, relational, repaired, maintained, and reconfigured' (Pink et al., 2022: 38). Digital Water as infrastructure is not a stable entity. It is not a question of leaving from 'somewhere' and arriving at a set destination. Digital Water as a phenomenon is always evolving, in the making, and integrated with new world-making capabilities. It is characterized by its promissory nature (Andersen, Astrid Oberborbeck & Jessen, 2023), which imbues it with a particular temporal orientation; a future-oriented promise of ecological relief and economic profit through the betterment of water flows. As Sarah Pink emphasizes, infrastructures signify not only in the here-and-now but entail also a prefiguration and anticipation of potential futures (Pink et al., 2022). Through their ability to enact certain future imaginaries, infrastructures of the present 'cast a shadow on the future, laying the foundations for daily practices in years and decades to come' (Shove et al., 2019). From this perspective, as manifestations of certain future anticipations,

or of a longing for something that lies beyond the horizon of conceptualization (Ingold, 2022), infrastructures can be seen as existing in the domain of the uncertain and contestable (Adams et al., 2009). While digital water technologies and the quantified predictions that they produce already provide 'useful frames through which to consider possible futures' (Pink et al., 2022: 37), these digital forms of future anticipations (Pink et al., 2023) are always also mediated, contested, 'tempered, re-shaped, and ideally always constituted relationally with qualitative, embedded and experiential human ways of knowing and imagining the present and possible futures' (Pink et al., 2022: 37; see also Chapter 6).

In emphasizing the temporal, relational, unbounded, processual, and generative nature of infrastructure, I draw on a growing scholarship on a 'futures anthropology' (Lanzeni et al., 2023; Pink et al., 2016; Pink, 2021; Pink et al., 2022; Salazar et al., 2017). These scholars address 'diverse temporalities of anticipation, imagined futures, and possible worlds' (Pink, 2022: 1). They perform engaged, critical, and novel forms of interdisciplinary ethnography and multi-stakeholder collaborations, and they call 'for a renewed, open, and future-focused approach to understanding the present, anticipating the unknown, and intervening in the world' (Pink & Salazar, 2017: 3). According to these scholars, studying 'futures' does not imply the study of predetermined or predicted future situations as is the case of predictive sciences within computation and engineering. Drawing on the tradition of design anthropology, an anthropology of futures seeks *possibility*, not prediction (Pink, 2021: 195; Smith & Otto, 2016). As Pink phrases it, 'It refers to the to the question of how we research things that could happen, how do we encounter moments or temporalities in the present which invoke possible futures (or alterities) experientially, and subsequently what methods

and concepts might best help us to document, understand, or intervene in them?' (Pink, 2022: 4).

Infrastructures and/as Open-ended Experiments

Building on these reflections, I follow anthropologists Casper Bruun Jensen and Atsuro Morita in my approach to Digital Water, as they perceive infrastructures as emergent systems that *produce* novel configurations of the world – or what they refer to as 'new practical ontologies' (Jensen & Morita, 2017: 4). Because infrastructures at once integrate a multiplicity of disjunctive elements *and* spin out new relations between them, Jensen and Morita suggest that infrastructures should be approached as '*open-ended experimental systems*', the outcomes of which *give form* to culture, society, and politics (ibid. 3). From this perspective, the experimental dimension of infrastructure is largely due to the varied practices and historical, technical, and geographical conditions that infrastructures connect. The effect of these processes is, Jensen and Morita argue, 'a largely unpredictable set of infrastructural reconfigurations' which in turn re-compose practical ontologies (ibid. 5). In other words, seen as experimental systems that generate practical ontologies, infrastructures take actorship in the ongoing shaping of politics and power relations (c.f. von Schnitzler, 2008). In addition, recognizing the political future orientation and world-making potential of infrastructures makes Digital Water a form of 'anticipatory infrastructure' (Pink et al., 2022) through which possible futures come to be in practice and through which they in turn become ethnographically accessible. Perceiving Digital Water thus allowed me to engage with it as a phenomenon that enables trans-disciplinary encounters between water and data professionals, computer scientists and anthropologists in shared ponderings about potential water

futures (see Chapter 7). But also, as one that facilitates a sort of 'digitally enabled sociality', that reframes what it means to do diplomacy and to export water management technologies (see Chapter 5).

Beyond this, seeing digital water infrastructures as experimental systems opens room for engaging anthropology *with* Digital Water. This has important methodological and analytical implications that I unfold in the next chapter. Before doing so, however, let me dwell on the theoretical strands on which I draw when approaching Digital Water as an anticipatory and experimental system.

Collaborating *with* Digital Water

In her work on anticipatory infrastructures, Sarah Pink distinguishes between the study *of* and *about* futures, 'which tends to involve a more conventional mode of scholarship, seeking to understand, define, and possibly critique' (Pink, 2022: 4); and researching *in* possible futures. Studying *in* possible or speculative futures, she argues, 'seeks to move *with (and in) the times* – instead of studying *time as an object*' (ibid. 4). In the following pages, I explore the ways in which an ethnography *in/with* Digital Water as an anticipatory infrastructure might elicit collaborative and 'engaged' (Svendsen, 2009) modes of performing critique which acknowledge that 'critique is always already present' (Birkbak et al., 2015: 5) in the situations and among the interlocutors that I engage with.

I have already touched upon how this study is not only an ethnography *of* Digital Water – an account of how the smartification of water management engages different actors in the Danish water sector and beyond – but also an anthropology *with* Digital Water. Not in the sense of it contributing directly

to the development of novel methods that integrate 'big' and 'thick' data (Bornakke & Due, 2018) into ethnographic fieldwork practice, nor is it an attempt to redefine 'anthropology *as* data science' (Pedersen, M. A., 2023). While I sympathize with the recent experimentations aimed at crafting a machinic, computational, or AI anthropology (Munk & Winthereik, 2022; Munk et al., 2022; Pedersen, M. A., 2023), my aim here is somewhat different, although cognate to them. Inspired by the work of Tim Ingold (2011), I acknowledge the open-endedness and emergent nature of Digital Water understood as a composite, heterogeneous, more-than-human, yet enmeshed ecology of actors, materials, forms of information, data, and practices. Rather than an attempt to reframe anthropology through computational methods, this dissertation aims instead to practice an anthropology that works in *correspondence* (ibid. 241; Ingold, 2017) with the ecology of actors and practices that makes up Digital Water. One that inevitably contributes to its becoming. This exposes the struggle of an anthropology that is deeply woven into close collaborations *with* its interlocutors, while also trying to retain the distance and critical glance of an 'anthropology *of*'. The struggle of an anthropology in tension between its loyalty to the character of its discipline and knowledge production and to the position and epistemic partners with whom that very knowledge is produced.

To address these struggles, I draw from an anthropology that is distinguished from, yet critically engaged (Svendsen, 2009), contributing to, and in conversation with the multivalent actors and forms of knowing through which Digital Water continuously and ongoingly emerges. In navigating between its collaborative impetus and the effort of retaining anthropology's commitment to criticism (Strathern, 2006), my ethnographic approach is one of critical proximity (Birkbak et al., 2015); one that resembles what Mette My Madsen,

Anders Blok, and Morten Axel Pedersen address as 'transversal collaborations', or 'forms of non-coherent, intermittent and yet productive mutual co-creation among partially connected knowledge practices and practitioners' (Madsen et al., 2018: 187). In this sense, this is not a machinic anthropology, but rather an 'analogue' anthropology, as Frida Hastrup (2014) puts it, understood as one that works across – and in dialogue with – different epistemological, material, disciplinary, and geographical divides. It is an anthropology that aims at showing how Digital Water emerges as a composite ecosystem by moving *athwart* (Helmreich, 2009) those different perspectives in thinking *with* and *of* them.

Having positioned myself within these theoretical frameworks, in the next chapter I address the methodological implications of perceiving Digital Water as an anticipatory infrastructure and 'open-ended experimental system' (Jensen & Morita, 2017).

Chapter 4. Navigating Digital Water
A methodological *ouverture*

In this chapter, I take a closer look at the different kinds of ethnographic data that framed my methodological and analytical choices and how, where, and with whom it was generated. This dissertation rests on ethnographic data generated through 12 months of fieldwork across 10+ sites, 150+ interlocutors, and two countries.

I start by describing my ethnographic path (Sanjek, 1990): how I discovered the various field sites that I have visited and interlocutors that I have engaged with, how I gained access to them, and how they are connected. Although these field sites and approaches may seem disjointed, taken together, these choices and movements compose a single ethnographic field: the ecosystem of Digital Water. I also offer an overview of the ethnographic data that came out of my fieldwork and review their quality and analytic potential along the way. Finally, I reflect on my notetaking practice, role, positioning, and ethical considerations when engaging with Digital Water.

I chose to present my fieldwork approaches, methods, sites, and reflections in some detail. With this, I hope to transmit a sense of transparency about my ethnographic process. Besides, as Vogel observes, how we organise our methods 'invites particular forms of analysis and not others. In this sense, methods are part of our analytical practice' (Vogel, 2021: 56). Describing the details to which I was particularly attentive during fieldwork, including the methods and sensibilities that I employed during my data collection, serves a dual purpose. Firstly, it offers a backdrop to the analytical perspectives and reflections that I raise in the next chapter. Secondly, it is also a gentle

invitation for you, as readers, to think with and about this dissertation alongside and against the contributions that it offers (cf. Fortun, 2003).

Assembling the field: A roadmap to Digital Water

As I mentioned earlier, following Fortun, I perceive Digital Water as an open (eco)system that I engage through ethnography as an open system (Fortun, 2003). Methodologically, this implies that I meet Digital Water with an attentiveness to understanding how data and water are continuously reconfigured into new social, political, and material assemblages that continuously leak, spill over, and inform one another. Dealing with such a fluid object of study has produced an ethnography which is not only distributed in the sense of not being bound to a single field site (Candea, 2007) but also one that is shaped through various forms of experimental, interventionist, and future-oriented collaborations (Ballestero & Winthereik, 2021). To render how the project took form methodologically, I offer a brief timeline of my methodological engagement in the field.

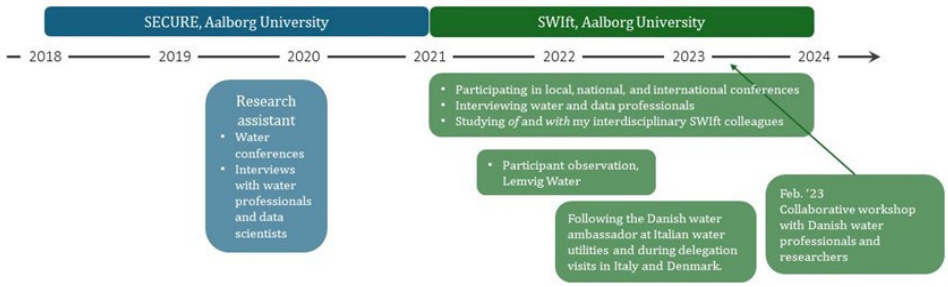

Figure 2: *Timeline of my fieldwork and research work. Credit, Jonas Falzarano Jessen*

This project came out of my prior work with the interdisciplinary research project 'SECURE'[6] (2018-2021) at Aalborg University. The engineering-led project aimed at developing encrypted, secure, and computationally optimized models for the management of critical infrastructure, including water supply, with anthropology's contribution being to relate new computational techniques to use cases and to a human, social dimension. My involvement began in 2019 as a research assistant. Over 6 months, I generated qualitative data about the attitudes among Danish water professionals towards data security in the context of digitalizing key water management processes. During this preliminary fieldwork, I participated in SECURE team meetings, local and national conferences, and seminars about the digitalization of water management. I also conducted desk research and explorative literature reviews on emic reports and industry documents on water management and digitalization in Denmark. I conducted nine semi-structured interviews with water professionals and data scientists working in the Danish water sector. These included interlocutors from small/medium-sized Danish water utility companies, public organisations working with water and digitalizing public infrastructure, Danish consultancy companies, and private enterprises. Although I did not realise it then, this preliminary investigation functioned as a kind of pilot project for my role in the SWIft project. I learned that the Danish water sector faces a series of ideological, political, and economic pressures towards digitalizing key water management practices. Whether they stem from neo-liberal approaches to the commodification of water and data management or the idea of commons, these pressures seem to perceive the digitalization of water as a necessary and unavoidable transformation of water

[6] SECURE is an acronym for Secure Estimation and Control using Recursion and Encryption

management practices. As such, my work for SECURE gave me an overview of the core actors within – and concerns about – digitalizing water management in Denmark.

Thus, I already had some knowledge of the Danish water sector when I began my Ph.D. with the SWIft project (2021-2024) which was led by the same engineering Principal Investigators as SECURE. With the SWIft project, my ethnography has focused on how digitalization shifts working practices at water utility companies and how Danish water solutions become scalable and travel to other contexts. Furthermore, my engineering colleagues were interested in gaining an overview of the digital readiness of Danish water utility companies and of the barriers and incentives to adopt digital tools among water utility employees through my ethnographic research.

Building on my earlier interactions, I began participating and contributing to local, national, and international conferences about water management and digitalization in early 2021. I started by participating in these conferences as a *participant observant*. However, over time, as my research progressed and as other actors became acquainted with me and my work, my role slowly began to shift, and so did my methodological approach to conferencing. My interlocutors began to gain interest in – and expectations of – my research. So, I began to contribute, and no longer only participate passively, to conferences. I practised *observant participation,* if you want. This generated different kinds of data and relations to the field.

Although less frequently, I continued to participate in some of these events up till the summer of 2024, as I finished writing this dissertation. Conferencing helped me map out the relations between some of the actors

that populate the Danish water sector, some of which became my key interlocutors, and how they interact, collaborate, and compete. My regular participation in water conferences also allowed me to set up formal interviews with a range of water professionals from across Denmark. These interviews helped me expand my understanding of Digital Water and opened access to new fields and opportunities for participant observation that have helped shape my research. Through these encounters, I became aware of the current political incentives of the Danish Government for expanding the Danish export of water technologies through diplomatic efforts and by using Danish water utilities as platforms to showcase Danish efficiency within water management. Based on the position I had begun to establish for myself in the 'Danish Digital Water scene', I was offered the opportunity to conduct participant observation at Lemvig Water in the summer of 2021 and later to follow the Danish water ambassador in his work exporting Danish water technologies and solutions to Italy in the summer of 2022. Getting access to these fields proved to be surprisingly easy. I believe this to be partly due to my persistent participation in water conferences and the good foundation I had built during the SECURE project. Many of the other regular participants had become accustomed to me and, to some extent, seemed to be somehow captivated by what anthropology might offer to help them navigate the emergence of Digital Water.

In February 2023, as I began shifting my focus from doing ethnographic fieldwork to analysis, I developed a collaborative workshop to bring together the different kinds of interlocutors, field sites, imaginaries, and practices that I had encountered during fieldwork to speculate on the relation between human and artificial intelligence within water management with my interlocutors in a collaborative, future-oriented, and interventionist manner.

This workshop was only made possible after I had made connections throughout the Danish water sector. At this point, I had generated insights from white papers, from the perspectives of engineering, from Digital Water as business and politics, and practice at water utilities. Only by having done so, I was able to bring these diverse actors together to speculate about Digital Water futures. While generating new ethnographic insights and data, the workshop also represents the culmination of the knowledge that I generated through fieldwork and formed an intervention to the emergence of Digital Water.

Building further on this brief timeline, in what follows I map out my 'field' according to the locations, kinds of sites, and interlocutors that I have encountered and with which I have engaged. Thereafter, I offer a list of the ethnographic materials upon which I base my analyses. With this detailed presentation of the contours of my field, I will then present the methods I used and why I used them. I end this methodological chapter with a reflection on my ethical considerations and positioning during the project.

Locations

My fieldwork was carried out in Denmark and Italy. As we have seen in the introductory chapter, the idea of Digital Water emanates from various industrial and political reports on the (potential) future of water management. Amongst these countries, Denmark ranks as one of the most digitalized in the world (European Commission, 2022). Furthermore, the recently published *Export Strategy for Water* (The Danish Government, 2021) and a series of other Danish policy papers (see e.g. CALL Copenhagen, 2018; Mikkelsen et al., 2019) testify to the weight of the Digital Water agenda within the Danish water sector. Thus, Denmark seemed to be the right place for studying the

emergence of Digital Water. As I have shown in brief earlier, in Denmark, Digital Water is a strategy for development, innovation, climate relief, and profit that can be scaled and adapted to other contexts to export Danish water solutions. As mentioned in Chapter 2, the Danish Export Strategy for Water estimates that Italy will be one of the European countries to invest most heavily in renovating its water infrastructure in the coming years. This makes it a new potential market for Danish water solutions and thus a promising location to study the scaling of Digital Water. Along with Italy, the Strategy also perceives countries such as Spain, Portugal, Poland, and Germany in Europe, but also the U.S. and India as promising 'markets' for Danish water solutions. However, given the opportunity, my final decision to do fieldwork in Italy was practical: I am a native Danish-Italian bilingual.

Kinds of Sites

Documents and reports

As I mentioned in the introduction, I have assembled my ethnographic field by following the connections of practices, imaginaries, and discourses that make up the ecosystem of Digital Water. In addition to the Danish and Italian national contexts, mapping this ecosystem has brought me to multiple other kinds of sites, where I generated my ethnographic material.

The first 'kind' of site that I encountered during fieldwork was populated by reports, policy papers, and white papers on the digitalization of water management practices written by Danish private water technology companies (Grundfos, 2022; Kamstrup, 2024) as well as state and government agencies, water utility companies, interest organisations (Aarhus Vand, 2018; Aarhus Vand, 2024; CALL Copenhagen, 2018; Mikkelsen et al., 2019), and

international institutions (Cosgrove & Rijsberman, 2000; IWA, 2019; IWA, 2020; World Economic Forum, 2018). This is different from an academic literature review because these are publications published and read by my interlocutors. In that sense, these documents form their own kind of field site (Abram, 2003; Shore & Wright, 1997). I explored this site comprehensively to get a grasp of the emic discourses surrounding Digital Water. Furthermore, exploring this site also gave me an overview of the Danish water sector, how it is constituted – its main actors, institutions, and legislation – and of its historicity and politics. I also studied academic papers on the development, use, and integration of digital data systems in water management from an engineering (Figueiredo et al., 2021; Pedersen, A. N. et al., 2021) and social sciences perspective (Popartan et al., 2022; Walter, 2024). This helped me get a grasp of the current academic approaches to the development and business of Digital Water and their ways of affecting each other.

Business sites

Another fruitful kind of site for my fieldwork is what I refer to as 'business sites'. This category includes industrial conferences, public debates, professional and private meetings, workshops, and seminars concerning the digitalization of water management in Denmark and Italy. I participated in 25+ such business events. These events included (but were far from limited to) the yearly Danish Water Conference (*Dansk Vand konference*) which was organised in Aarhus in 2022 by the Danish association of water utility companies DANVA; the international IWA World Water Congress & Exhibition (WWCE), which was held in Copenhagen in 2022; the 2022 Danish national climate conference (*det Nationale Klimatopmøde*) organised by the water utility of Lemvig, and the yearly Italian Water Festival (*Festival dell'Acqua*), which was held in Turin, Italy, also in 2022, in addition to other

events and seminars about the digitalization of water and the Danish water sector. Participating in these events helped me become familiar – and engage – with key actors, challenges, and concerns in the Danish and Italian water management scene in practice, and it was by taking part in those events that I slowly began to position myself as an actor within my field and among my interlocutors.

These sites were populated by key actors of the Danish water sector, making it an important site to my research. Conference participation helped me make connections that gave me access to a range of Danish and Italian water utility companies where I conducted interviews and participant observation. I also paid visits to five Danish private water technology companies based in Denmark and Italy, such as the Danish and Italian headquarters of a major Danish water technology company. These five companies play a central role in the emergence of Digital Water in Denmark as they are among the main beneficiaries of expanding the market for Danish water technologies. Moving my fieldwork across these sites helped me generate knowledge on how Digital Water is performed in practice, how it reaches beyond local practices of water management, and across geographical boundaries and diverse kinds of actors.

Water utility companies

Water utility companies make up a kind of field site too. I did fieldwork at seven water utility companies. I visited offices, pumping stations, wastewater treatment plants, and climate change adaptation systems, and walked through plenty of muddy fields trying to detect leaky water pipes across the cities of Aalborg, Aarhus, Brønderslev, and Lemvig in Denmark and Reggio Emilia, Rapallo, and Venice in Italy. At these kinds of sites, I dealt with the everyday

and practical management of water flows and the implications of Danish (digital water) politics on a local scale in Denmark and Italy.

The Laboratory

The SWIft laboratory at Aalborg University makes up another kind of site. While I did not directly take part in the day-to-day laboratory work of my SWIft colleagues, throughout the length of my research I have participated in team meetings, discussions, and ethnographic interventions conducted at the Lab. These meetings have ongoingly given direction to my ethnographic attentiveness during fieldwork, and they have helped generate a shared language and framework for the overall SWIft research project. They have also been characterised by a great deal of interdisciplinary confusion, misunderstandings, mutually unfulfilled expectations, and frustrations. Nonetheless, on some occasions, these tensions proved also to be generative and stimulating (see Chapter 7).

Para-sites

A final sort of field site that has been quite generative and characteristic for this dissertation consists of the workshop on 'Human and Artificial Intelligence in Future Water Systems' that I facilitated with support from my colleagues at SWIft and some of my interlocutors. I consider this a kind of field site on its own – a 'para-site' (Marcus, 2000; 2022). In doing so, I build on recent calls within ethnographic and anthropological practice for 'experimenting with ethnography', 'experimental collaborations', for crafting 'para-sites' or 'third spaces', and to build an 'interventional futures anthropology' (Ballestero & Winthereik, 2021; Estalella & Criado, 2018; Marcus, 2013; Salazar et al., 2017). These forms of experimental and collaborative ethnographic practice, which have gained currency in recent

ethnographic scholarship, perceive experimentation as fieldwork devices that allow for mutual learning and reflection among ethnographers *and* their interlocutors in the field (Estalella & Criado, 2018: 21). Along these lines, George Marcus has devised the notion of ethnographic 'para-sites' to address bounded spaces – design workshops, archives, interactive websites or so – of orchestrated interactions between different actors engaged in collaborative fieldwork projects. These spaces are 'both within the activities of a particular fieldwork project and markedly outside or alongside it – or lateral to it (cf. Maurer, 2011)' (Marcus, 2013: 210). Not exactly outside of the conventional ethnographic field nor completely part of it, but rather alongside or adjacent to it (Rabinow, 2008), the para-site affords, according to Marcus, a space of ethnographic data generation and analysis through reflexive encounters between the ethnographer and his/her interlocutors, which he perceives as 'epistemic partners' (Holmes & Marcus, 2007).

Inspired by Marcus, and in the attempt to tie the ecosystem of Digital Water that I had encountered during fieldwork together in an explorative, generative, and future-oriented way, I planned, designed, and conducted an ethnographic workshop along with my SWIft colleagues, and in partnership with some of my interlocutors from the consultancy company 'WADE'. The workshop took place on February 2nd, 2023, at the Aalborg University Smart Water Infrastructures laboratory facilities and gathered representatives from five different Danish water utility companies, one consultancy company, the SWIft research team members, and six ethnographers in a collective exploration of what it means to digitalize water management now and what it might imply in the future.

These sites can be categorized into two overarching groups: as spaces where the idea of Digital Water is crafted, and where its consequences are felt and create friction (Tsing, 2005) with everyday water management practices.

Interlocutors

As for the abovementioned kinds of sites, I categorize my interlocutors as either Digital Water *pioneers* or Digital Water *practitioners*. The former include actors whose imaginaries, strategies, and practices shape the emergence of Digital Water as a concept. These are actors who develop visions and advocate for the expansion of digital solutions for water crisis relief and economic profit. They include certain industry and water utility leaders, policymakers, local and international state officials, politicians, and researchers, including my SWIft colleagues. The visions of these actors have served as an ethnographic point of departure to study how Digital Water aspirations and discourses have actual world-making implications among other actors, including water utility employees. The latter, instead, include water professionals and operators at water utility employees and water technology companies. These actors do not necessarily claim the vision of Digital Water as theirs (although some do), others speak openly against digitalization as a pathway to improve water flows. What unites them, however, is that their everyday practices are affected by the Digital Water agenda and that, in performing their job, they too indirectly contribute to – or work against – the emergence and scaling of Digital Water.

The sort of mobile ethnography (Marcus, 1995: 96) through which I have assembled the phenomenon of Digital Water from across multiple kinds of field sites and localities, was only possible through countless ethnographic conversations, coffee-break dialogues, and interview situations with the

various actors that populate these sites. I have interacted ethnographically with over 150 actors. These interlocutors include state officials, representatives from private IT and water technology businesses, consultancy companies within engineering and IT, public and state institutions, interest organisations, employees and board members of water utility companies, and researchers from my SWIft team and beyond. Specifically, I have engaged with field operators, engineers, directors, and digital data supervision, control, and visualization software from the water utility companies of the Danish cities of Aalborg, Aarhus, Brønderslev, Copenhagen, Kolding, Lemvig, and Randers as well as from the Italian cities of Rapallo and Reggio Emilia. In the next chapters, we shall meet a handful of them, including Brad from Lemvig Water, who has been a dear and key interlocutor during my fieldwork. I also engaged with state officials from the Danish embassy in Rome, including Liam, the Danish water ambassador in Italy, whom we shall meet in Chapter 5, and from the Trade Council, which is part of the Ministry of Foreign Affairs of Denmark. In meeting and doing participant observation among these actors, I aimed to conduct and produce an ethnographic account *of* Digital Water as it emerges across and through their diverse practices and imaginaries.

Finally, throughout the length of my fieldwork, I have ongoingly discussed, sparred, and done participant observation with my SWIft colleagues at Aalborg University and with engineering consultants from 'WADE Consulting'. Among them, Peter has been a key collaborator who has helped me conceive and organize the workshop that I mentioned earlier. My work with these actors has been inherently collaborative. Doing ethnographic explorations *with* these actors was aimed at developing shared and mutually

beneficial insights, which effectively characterized them as my ‘epistemic partners’ (Holmes & Marcus, 2008).

Ethnographic Data

My literature reviews of emic sector-specific white papers and reports have generated ~40 pages of notes and reflections. Through my participation and contribution to sector-specific business conferences, more than 15 in total, I have generated ethnographic material resulting in ~60 pages of ethnographic field notes, 150+ photos, 5 recorded panel debates and discussions for a total of 3 hours of audio material and 30 pages of transcriptions. It also includes slides from 15+ PowerPoint presentations from a variety of actors within the Danish and Italian water sectors. I also prepared and conducted four paper presentations of my research at sector-specific conferences for audiences consisting primarily of water professionals. Furthermore, I produced two written contributions about my research to a Danish engineering and tech journal, one of which was written as a position paper in collaboration with some of my interlocutors and colleagues (Jessen et al., 2023a). These contributions form part of my collaborative approach to fieldwork.

I also produced ~65 pages of fieldnotes and 350+ photos, drawings, and illustrations from participant observation at seven water utility companies and five private water technology companies in Denmark and Italy. I conducted ~40 unstructured to semi-structured interviews. Out of these, 25 were with water professionals, computational experts, the Danish water ambassadors, and public officials, amounting to ~21 hours of taped interview material.

Finally, the workshop ‘Human and Artificial Intelligence in Future Water Systems’ generated a whopping multimodal and heterogeneous ethnographic

dataset consisting of ~45 pages of fieldnotes written from the perspectives of six different ethnographers (including students, academic researchers, and an anthropologist working at a Danish consultancy company), ~240 minutes of video recordings from presentations and hands-on laboratory exercises conducted by the workshop participants, 170 photos taken by 3 different ethnographers, ~9 hours of recordings, and ~25 pages of fieldnotes from the planning ahead of the workshop and reflections after it, along with three visual documentations of the workshop created by a hired graphic documentarist. All this material was generated according to methodological choices that evolved throughout the project and along with my growing analytical insight. That is the topic of the next sections in this chapter.

On Methods

I generated these materials through classic ethnographic methods and a pinch of experimental practice. First of all, studying documents and policy papers was an integral part of my fieldwork as they are some of the main ways in which interlocutors across the field of Digital Water engage with one another across geographical and institutional divides. Nonetheless, my interest in Digital Water goes beyond discourses, which is why I needed to engage with how Digital Water is enacted in practice. In this section, I introduce the different kinds of methods I used during fieldwork, always tailored to the specific context – national, business, utility, conference, laboratory, intervention etc. – and to the interlocutor with whom I engaged – an academic, a consultant, a political actor, a utility worker, businesspeople and so on. Although the different kinds of ethnographic techniques that I employ tend to overlap, in what follows I categorize the methods that I employ throughout my fieldwork as laboratory studies, participant observation 'by appointment'

or by ‘following Digital Water’, through interviews, and finally as intervention. I do so to give the reader an impression of the different methodological approaches through which I have produced my ethnographic material, my thoughts behind those choices, and the scholarly approaches that I draw on by using them. I conclude with some reflections on ethics.

Laboratory studies

Laboratory work and interaction with my SWIft colleagues played a significant role in shaping this Ph.D.-project. During my fieldwork, particularly in its beginning, I spent time at Aalborg University with my engineering colleagues to better understand how potential digital innovations within water management emerge from the laboratory. Inspired by methodological approaches within anthropology and STS to the practices and social relations involved in the construction of scientific facts (Latour & Woolgar, 1979; Law, 1992; Traweek, 1988), I paid particular attention to the assumptions, expectations, and knowledge gaps that my colleagues had on behalf of their work and the working habits and technological advancement of actual water utility companies. I took detailed notes about their vocabulary, practices, and expectations of algorithms and digital technologies. I also observed the way we collaborated in our research team, what my colleagues expected of me as an anthropologist, and how they envisioned ethnography would contribute to the overall project. These notes were oriented towards getting to know my colleagues and capturing the nuances of our interdisciplinary collaboration. While I knew that my ethnography could not offer exactly what my colleagues expected of it, namely predictions on human behaviour on specific occasions, doing participant observation at the Lab and in conversation with my SWIft colleagues helped direct my ethnographic gaze during my fieldwork beyond the laboratory. As my colleagues asked me,

I would ask myself: how do water utility employees make important decisions about water management? What kinds of negotiations about infrastructure management take place at water utilities? Between whom? What *is* Digital Water for water professionals in practice? I brought these questions with me as I followed different materializations of Digital Water at other fieldwork sites.

Participant observation… By appointment

I have conducted a great deal of what Ulf Hannerz addresses as 'anthropology by appointment' (Hannerz, 2006: 34). Much of my ethnographic work was marked by the limited time of my interlocutors, many of whom are water professionals with their schedules packed with meetings and other tasks. The rhythm and pace of my fieldwork were thus strongly affected by my regulated access to certain forms of information, practices, and actors that were granted to me during e.g. meetings, conferences, seminars, and workshops in which I assiduously participated through the length of my fieldwork. Initially, I welcomed these occasions as ways to meet key stakeholders in the Danish and international water arenas as well as a way to get a grasp of how they interact as a 'community of practice' (Lave & Wenger, 1992; Star & Ruhleder, 1996) around the digitalization of water management.

My participation in events and conferences was, by their nature, dictated by clearly delimited constraints in terms of time and scope of the events, which accommodated presentations punctuated by short formal interactions above in-depth ethnographic conversations. I learned to use such occasions to make time-space in the busy schedules of my interlocutors to contribute to my research. As I elucidate in Chapter 5, it was my participation at one such event that I met Liam, the Danish water ambassador in Italy who then granted me

access to several weeks of ethnographic fieldwork along with him in Italy and Denmark. While participating in business events was generative in this sense, it did not allow me to fashion the deeper relationships that typically originate from conventional long-term fieldwork 'by immersion' (Hannerz, 2006) and which, over time, make time-space for the unexpected, for moments of serendipity. Indeed, it is common knowledge in anthropology that doing 'ethnography at home' requires specific methodological and analytical strategies aimed at 'making the familiar strange rather than the strange familiar' (Van Maanen, 1995: 20). Therefore, I did not join events and conferences only as a participant *observer*. I found that actively contributing to conferences by giving (at times slightly provocative) paper presentations or by publishing written contributions to sector-specific journals about my research, allowed me to elicit unforeseen opportunities and productive discussions that either validated, refuted, or nuanced my ethnographic findings. These contributions marked a subtle, yet significant shift in my approach to doing participant observation: from being predominantly *observant* to *participatory* (Holy, 1984; Moeran, 2009). Intervening through paper presentations at water sector-specific conferences, helped me open a getaway for fruitful conversations and, in its aftermath, for me to reflect on how to engage my ethnography productively in interdisciplinary collaborations by tacking back and forth between different forms of translation, intervention, and collaborative critical thinking across disparate actors. As a result, though, my position as a researcher also became increasingly entrenched and involved with that of my interlocutors. I will return to this later in this chapter.

Following Digital Water

This leads me to a different kind of method, one that might be seen as 'multi-sited' (Marcus, 1995). What binds the different sites that I have dwelled on thus far together is that they reflect different materializations of Digital Water as it comes to be debated, contested, and shaped in practice across different sites, actors, and situations. Following Digital Water across different sites became a way for me to juxtapose my observations from the laboratory and what I had studied on policy papers and other documents – including the imaginaries, beliefs, and promises attached to them – with its 'daily use' in practice. This brought me to Lemvig and several Danish and Italian water utilities as I followed the Danish water ambassador in Italy. To prepare for my conversations with Italian and Danish water experts, I have studied the socio-technical, geographical, and cultural dimensions that shape water management practices in both countries.

In Lemvig I conducted two months of ethnographic fieldwork among water utility employees, following their daily activities and interactions with more-or-less digital water technologies. On my first day of fieldwork at Lemvig Water, I received a desk and a screen in an open office space along with the local utility employees. I made a point of keeping a work routine that resembled the workday of my interlocutors. I turned up at 7 am and left at 4 pm and spent most of my time along with the water utility operators – either working with the maintenance of the water pipes somewhere in the area supplied by the utility or supervising their digital renderings on the SCADA from the office. In Lemvig, I encountered a variety of analogue and digital solutions that assisted utility employees in getting to know and make sense of the water system. I became interested in how these solutions work by augmenting the employees' ability to sense water flows and, by extension,

also their *sense* of the water infrastructure. I had layered and complex discussions with utility employees about the kinds of skills, modes of sense-making, and situated knowledges that are activated in the process of getting to know and understand the inner workings of different fluxes of water in specific parts of the network – and how to manage them. I oriented my attention toward practicalities. I wrote descriptive, explorative, and detailed fieldnotes about how certain functions had been digitized and the effects of this; about what might be digitized, and what really could not. I wanted this part of my work to attend to the 'gaps between visions and implementations' (Fischer, 2018: 4) of Digital Water. I wanted to foreground the similarities and differences between what I had experienced in the Lab and my colleagues' expectations of Digital Water on the one hand, and the day-to-day experience of digital water management at water utility companies on the other.

I also followed the work of the Danish water ambassador in Italy for roughly two months over several visits. I did participant observation alongside the water ambassador during Danish delegation visits in Venice, during his 'fact-finding trips' in the Italian cities of Reggio Emilia and Rapallo, at Danish water companies based in Italy, and during his visits at Danish water utility companies such as Aarhus Water along with Italian visiting delegations. I also participated at conferences such as the Italian Water Festival in Turin, at workshops, and in the travelling in-between. Following the Danish water ambassador, I learned how ideas of economic expansion and scalability emerge out of and are inherently stored within the idea of Digital Water.

Interviews

As I engaged with my interlocutors during participant observation, the boundaries between interviewing, participation in meetings, conducting focus group interviews, networking, and having ethnographic and intellectual conversations were often blurred. Nevertheless, I distinguish between the multitude of conversations that I have had during fieldwork and interviews based on the degree to which they were inspired by previously prepared interview guides. Some of my interviews were conducted spontaneously during my ethnographic fieldwork in Lemvig and Italy or after the meetings, seminars, or conferences in which we both participated. In most cases, however, my interlocutors and I would schedule an interview at their office after meeting at one of the many conferences and water events that I took part in. Many of my interviews are a result of either my networking efforts at water events or an outcome of my interlocutors' interest in my paper presentations at conferences. By agreement with my interlocutors, I recorded all my formal, semi-structured interviews for later re-listening, transcription, coding, and analysis (Bernard, 2006b). The remaining interviews were conducted in a more unstructured manner or as ethnographic conversations. While I still consider these to be interviews, they were more informal: these interviews were not recorded, but I kept track of them during or after the conversations through jottings and subsequently through detailed notetaking (Bernard, 2006a).

I also facilitated four group interviews, one with three members of a Danish water utility company, another with five employees at the Italian headquarters of a Danish water technology company, one with two consultants from WADE and an employee from a Danish water utility company, finally I also facilitated a group discussion with three members of the SWIft research team

and three consultants from WADE. Only one of these group interviews was originally intended as such. The others were either intended as interviews with a single person or started as simple meetings and discussions but turned into 'focused group interviews' (Schensul, 1999) situations as I took advantage of these conversations to ask important questions to my research.

I also interviewed my SWIft colleagues. At the beginning of my fieldwork, I used these interviews and informal conversations to get a grasp of what they expected of me as an anthropologist in terms of the overall goals of the research project. Later, however, I also used my interactions with my colleagues in SWIft to produce ethnographic insights about how Digital Water emerges within academic research practices and to stimulate mutual reflections on how to study – and contribute to the emergence of – Digital Water through collaborative and interdisciplinary synergies.

Interventions

With this project, I do not just want to describe and understand Digital Water. My aim is also to use ethnography to intervene in both practice and analysis (within anthropology and in the Danish water sector). I wanted it to offer ethnographic alternatives, or at least a pinch of nuance, to the notions of 'optimization', 'smartness', and 'efficiency' by digitalization that dominate current water management discourses. This approach builds on the legacy of pioneering work within STS and followed by the anthropology of emerging science and technology as a located and interventionist practice (Downey & Dumit, 1997). Similar discussions have also been facilitated within design anthropology, where ethnographic interventions are envisioned as conceptual, practical, and often collaborative inquiries into potential futures among ethnographer and interlocutor(s) (Smith & Otto, 2016). It may also

be seen as part of a 'collaborative turn' in the anthropology of science and technology (Hastrup, K., 2018; Marcus, 2000; Niewöhner, 2016) and as a contribution to an experimental approach to ethnography (Ballestero & Winthereik, 2021; Estalella & Criado, 2018; Fischer, 2018).

During fieldwork, I saw my interventions – through oral paper presentations at business events, written position papers, and workshop activities – as an opportunity to redirect my ethnographic observations from fieldwork back towards the field and the actors from which they originated. I saw this as a process of translation that allowed me to validate and nuance my observations. Ethnography is often referred to as a process of representation based on translations (between ethnographers and interlocutors and vice versa) (Spradley, 1979). Through paper presentations for the industry, I wanted to give my ethnography new life as a condensed and ethnographically informed narrative that spoke into the kinds of concerns and language of my interlocutors, yet in a slightly exotic and critical manner. Through this double translation – from interlocutors to ethnographer, and from ethnographer to interlocutors – I wanted to share 'unfamiliar stories about familiar practices' (Vogel, 2021: 56) with my interlocutors. By cultivating this form of strangeness through paper presentations, I hoped my ethnography would elicit productive friction (Tsing, 2005) and invite the audience to join me in making time-space for cross-sectoral and interdisciplinary moments of serendipity to arise.

Among my ethnographic interventions, the experimental workshop on 'Human and Artificial Intelligence in Future Water Systems', holds a particular function. For the workshop, I wanted to facilitate a space that assembled different perceptions, viewpoints, practices, and observations from

the various actors that I had encountered during fieldwork in a physical and reflective space. Anthropologist Else Vogel refers to this practice as one of *juxtaposition*, or 'the process of foregrounding and then contrasting particular elements in a messy and complex field' (Vogel, 2021: 53). I envisioned this as a way to carve out time-space to play reflectively with my interlocutors about ways of 'realizing worlds differently, constructing alternative futures' (Fischer, 2018: 3). The workshop was, in other words, a direct invitation for collaborative reflexivity in future-making for and with my interlocutors. I wanted to craft new modes of collective and trans-disciplinary thinking, modes that allow for the nuances of Digital Water to become ethnographically accessible and spur novel insights and serendipitous moments not only for myself and my research but also for the different actors that were assembled during the day.

To accentuate moments of juxtaposition, I pursued a particular notetaking strategy. Having assembled a team of six ethnographers, including university students, a Postdoctoral fellow, and a consultant, I instructed them to participate in different activities of the workshop. I tried to direct this multiple and distributed ethnographic gaze through a notetaking protocol (Billede), which I introduced to the ethnographers in advance of the workshop. I encouraged the ethnographers to think through this protocol during their observations and interactions with the participants of the workshop. I hoped that this would foreground eventual contrasting elements and complexities in their different observations. While this notetaking method did not generate direct commensurability between the different ethnographers' gazes, it allowed me, in retrospect, to 'observe' situations at the workshop that I could not attend to myself and gain a bigger and 'multiple' picture of the activities and impressions from the workshop.

Having collected all the different notes also allowed me to engage in productive discussions with each ethnographer during my analysis of the generated material and in preparation for this dissertation.

Ethnographer: [name]
Strategy: [e.g.: following a group of participants, following activity XXX]

Notes	Keywords / Coding
Where (location)? Activity XXX **Who (Observed participants)?**	
What (Short description of what you observed)	
How (Thick description of observations)	
Analytical comments/reflections of ethnographer	
Connections to other observations	
Photos	
Sound recordings	
Video	

Sensibilities

Words/language:

- What kinds of language/words do the participants use? Any similarities/differences?
  - Be specific about technical words
- How do they talk about digitalization and digital tools?
- How do the participants communicate internally as they work with the activities?
- Body language?

Mood

- How do the participants react to the activities? What's they degree of engagement?

Interactions:

- Between people
- Between people and artefacts/technologies

Hierarchies:

- Do you see clear hierarchies in the groups? How do you recognize them?
- Who is more and less active and talkative?

Misunderstandings and controversies:

- Describe eventual misunderstandings and controversies within the groups

Figure 3: *The notetaking protocol that I equipped the ethnographers that participated to the workshop with. Credit, Jonas Falzarano Jessen*

Ethical Considerations, Positioning, and Roles

Ethical considerations

My primary ethical considerations for this dissertation concern how best to render my observations and reflections from the field in a transparent manner, while also treating the anonymity and integrity of my interlocutors most respectfully. Working closely with organisations has posed certain limits to the degree of anonymity that I could grant without overly bending or obfuscating the context and nature of my ethnography.

For instance, granting Lemvig Water complete anonymity was never really a possibility. Firstly, local (digital) water management practices at water utility companies are geographically and culturally situated and contextual to such a degree that it would be either redundant not to refer to Lemvig or ethnographically thin to exclude those details. Secondly, the uptake of Digital Water in Lemvig is crucially related to its geographical position in Denmark – and to political and cultural imaginaries and reactions connected to this position. This has had implications for my writing about Lemvig Water employees.

While I have chosen to use pseudonyms for all my interlocutors, this does not always grant them complete anonymity. Occasionally, I have chosen to include the occupation or title (such as 'engineer', or 'CEO') of key interlocutors. I did so on occasions where I found this information to be crucial for the understanding of the hierarchies and social situations that I describe. On some occasions, I pursued other strategies to blur the identity of my interlocutors, such as developing composite characters. For instance, the figure of Liam, the 'Danish water ambassador', and Brad, the water utility operator from Lemvig cover various related actors to disclose the actual

identity of the single interlocutors. Where I could not grant full anonymity, I have asked for the verbal consent of my interlocutors before including them in this dissertation.

As I mentioned earlier, it was sometimes a challenge for me to distinguish between interviews, meetings, and casual conversations with my interlocutors due to their often improvised and causal character. During some of these rather informal ethnographic situations, my informants could happen to tell me something 'off the record'. As it is paramount for me to establish trustful relationships with my interlocutors, I have treated these concerns respectfully and excluded these sorts of particularly sensitive information from my conversations with other informants during fieldwork and from my writing. Nevertheless, these conversations have still informed my overall understanding and analysis of the situations that I took part in and their systemic relation to a wider context and environment. As such, they are still represented in the findings of this dissertation.

The one-day workshop on 'Human and artificial intelligence in future water systems' forms a particular case from an ethical viewpoint. The workshop received a great deal of attention from the Aalborg University communications department, which wanted to publish a story about the workshop on local media platforms. Thus, the workshop's participants were asked to sign an informed consent, allowing me to document the workshop with photos, video, sound recording, and written materials. Furthermore, the participants gave their consent for these data materials to be published in research and communication platforms with anonymised company and personal names.

Positioning and roles

While I have always been transparent about my official role as a researcher and anthropologist, during fieldwork I also used other positioning strategies. Reflecting the variety of field sites that I visited and the different affordances and interlocutors that populate them, I have partaken in different roles and pursued different positioning strategies during fieldwork. These different positionings shifted between degrees of *contribution* and *observation* and consequently took the form of different sorts of ethnography *of* and *with* my interlocutors and the ecosystem of Digital Water. For instance, as part of the SWIft research project, I was required to engage in close collaborations with my engineering colleagues, and my ethnography to contribute to the overall research goals of the project. However, since I consider the SWIft project a contribution to the emergence of Digital Water and my SWIft colleagues as Digital Water pioneers, I also regarded the SWIft researchers as interlocutors and my interaction with them as part of my ethnographic fieldwork. Accordingly, as I took part in business events, I quickly understood that participating actively would allow me to gain the interest and trust of the participants; to become 'someone', an expert on 'the human factor of Digital Water' that my interlocutors wanted to spar and share insights with. This tacking back and forth between practising an ethnography *of* and *with* my interlocutors has posed a challenge in terms of how to position myself as an ethnographer against my object of study and within my field. How could I uphold a form of 'involved' – and I would add, critical and productive – 'detachment' (Moeran, 2009: 14) while performing a collaborative and interventionist ethnographic practice? How would I deal with the risk that my research could indirectly contribute to legitimising the technologies and the practices that I aim to address critically? Having these questions in the back

of my mind helped me navigate between Digital Water critically and actively contributing to and shaping its emergence.

During my fieldwork at Italian water utilities along with the Danish water ambassador, we were often mistaken for being colleagues at the Danish Embassy in Rome by the actors that we met. Although I made a point out of clarifying my role as an independent researcher, I was often introduced by the ambassador as 'our Italian-speaking anthropologist from Denmark'. This seemed to have a positive effect both in terms of my access to the field and for the water ambassador. On behalf of my research, most of my Italian interlocutors seemed to be eager to contribute to a 'Danish research project supported by the Danish Embassy'. My work had somehow become qualified by my engagement with the Danish Embassy. On the other hand, my presence as a researcher (and translator) seemed also to put a stamp of approval on the authority of the ambassador in the eyes of his stakeholders.

Wrapping up and Looking Ahead

In this chapter, I have introduced the particularities of my fieldwork methods. Moving through the locations, kinds of field sites, interlocutors, my ethnographic data material, and the methodological choices that I have taken, I have sketched the contours of my ethnographic fieldwork and the data that it generated. I have shown how, as an ethnographer in an interdisciplinary research team, as a translator in international export relations, and as a facilitator of a workshop on Digital Water futures, throughout my fieldwork, I found myself contributing to the emergence of my ethnographic field and object of enquiry – Digital Water – by engaging in close collaboration with the actors that populate it. At the same time, I was in the ambiguous position of trying to study the practice of my close colleagues and of the interlocutors

with whom I collaborated while trying to retain some critical distance. This chapter concludes the first part of this dissertation. Beyond demonstrating my methodological choices, I have shown the geographical, historical, political, and discursive circumstances for the emergence of the idea of Digital Water. Furthermore, I situated this dissertation and its scholarly contributions in a theoretical framework within anthropological and STS studies of infrastructure.

Given all this, in the remainder of this dissertation, I turn to a more ethnographic and analytical mode. In the following three chapters, I seek to offer not only a glimpse of the complexity of Digital Water in-its-making, but also a *sensation* of it. Two of those chapters, Chapter 5 and Chapter 7, grow out of the scientific articles that are integral parts of this dissertation. Chapter 5 addresses the tension between diplomacy and export elicited by Digital Water. Building a case on the role of the 'Danish Water Ambassador', I argue that Digital Water is commodified, made scalable, and exported through storytelling and narrative practices. Chapter 7 explores the disciplinary tension between computer science, anthropology (and to some extent water engineering) in interdisciplinary and collaborative research projects. Drawing on experiences from two interdisciplinary research projects: the Aalborg University SECURE and SWIft projects, I argue, with Adrienne Mannov and Astrid Oberborbeck Andersen, that collaborations between anthropology, computational sciences, and water professionals that alter disciplinary boundaries and bridge epistemic differences can be accomplished through cross-disciplinary theoretical and epistemological engagements and the crafting of physical spaces for shared intellectual practices. Chapter 6 is, instead, curated as an essay. It is based on three ethnographic and speculative renderings of how digital water data and water utility operators collaborate in

managing water flows in Lemvig. It explores the tension between human and artificial forms of sensing and knowing within water leakage detection and management, and how these become distributed anew through Digital Water. It also dwells on how these different forms of human and machinic sensing and sensemaking were made legible, debated, and reconfigured during the collaborative workshop on 'Human and Artificial Intelligence in Future Water Systems'. I argue that the creation of such an ethnographic para-site (Marcus, 2000) opens a space of possibility for a critically engaged open-system ethnography of Digital Water.

Altogether, these chapters illustrate the empirical tensions I encountered during fieldwork and how I have used them to engage with – and intervene in – Digital Water. By setting these different chapters, and the stories they tell, up against each other – by pulling them together, in tension – I aim to render an immersive experience of Digital Water in its making.

Chapter 5. Scaling and exporting Digital Water

‘Water Valley Denmark’ opens

I felt lucky as I made my way to the conference hall in Aarhus, dressed up in some of my finest clothes on a Thursday morning, on June 9th, 2022. The official launch of ‘Water Valley Denmark’, the new Danish water innovation network based in Aarhus, Denmark’s second biggest city, had been branded by the organizers as a day of learning, networking, and celebration. It was completely sold out and with a long waiting list. The event invited key actors of the Danish water sector to celebrate the start of the initiative with a dialogue about the ‘possibilities of the Danish water sector for collaboration and increased export of Danish water technologies and know-how’ (Jørgensen, 2022).

The day started with a light lunch and networking. As I sat at my table, I recognized many faces that I had encountered or had hoped to meet during fieldwork. These included known faces such as the CEO and a handful of engineers that I had met at Lemvig Water, the newly appointed board of directors of Water Valley Denmark, and leading employees of other Danish water utilities and water technology companies. After lunch, we were officially welcomed by the chairman to celebrate Water Valley Denmark as a ‘world-leading foundation for global water innovation, an engine for Danish economic expansion, and a platform to show the world what Denmark is capable of’. These visions, as it became clear to me during the various presentations of the day, revolve around political ambitions of upscaling Danish water solutions to international markets and the development of new

commercial alliances to contribute to doubling the export of Danish water technologies by 2030 (The Danish Government, 2021).

The rest of the day offered keynote presentations about 'how to break the export curve', about how Chinese innovation is shaping global market trends, and about how entering international markets pays off both for the Danish state economy and private businesses. With inspirational talks from the perspective of other sectors such as the Danish wind energy industry, the talks that took place at the launch of Water Valley Denmark seemed to portray water management not only as a service but as an economic device too. More specifically, they presented the *digitalization* of water as a pathway not (only) for the betterment of local water services, but for market expansion and increased export. In the words of one of the participants in the launch, the CEO of a Danish IT company: 'We have a great deal of interest in digitalizing water [ed. water utility management processes] – for export purposes'.

By facilitating predominantly one-way communications in the form of presentations and speeches, events such as the launch of Water Valley Denmark are platforms where Digital Water is enacted in practice through staged performances by key actors of the Danish water sector. Scenes such as that of Water Valley Denmark, offer a glimpse of the sorts of aspirations, constellations, and predominant discourses that make up the ecosystem of Digital Water from the perspective of its Danish 'pioneers'. In this case, participating in the launch of Water Valley Denmark clarified to me how processes of digitalization, while being developed and showcased at Danish water utility companies as innovative solutions to local issues, are in fact closely related to ideas and practices of global export. In this process, Danish water utility companies play a central role in addressing and capitalizing on

‘global water challenges’. Furthermore, these business events also expose the actors, relations, interests, and alliances that make up the ecosystem of Digital Water in Denmark, allowing me to identify potential research pathways to pursue.

With this chapter, I dwell on one such research pathway which brought me to a range of Danish and Italian water utility companies by following how Digital Water takes material form through the diplomatic and commercial work of the Danish water ambassador at the Royal Danish Embassy in Rome. I do so by exploring the concept of ‘Water Diplomacy’ through an adapted version of the first of the two scientific articles that I include in this dissertation. The manuscript, entitled ‘Water Diplomacy. Scaling Stories in Denmark and Beyond’ is currently submitted and under review at the *Anthropological Journal of European Cultures* as part of a Special Issue on ‘Digital Sociality and Access: New Configurations of the Public and Private in the Nordics’.

Article A.

Water Diplomacy
Scaling Stories in Denmark and Beyond[7]

Jonas Falzarano Jessen

I am attending the launch of the 'Water Technology Advisory Europe' (WTA EU) via a video conference call. On my screen, I see five 'water ambassadors' – Danish water professionals located in Spain, Portugal, Poland, Germany, and Italy – and an audience of mainly technology and service providers from Danish water technology companies. The water ambassadors have just finished explaining how they will support the commercial ambitions of Danish water companies in their respective countries over the coming two years, and the meeting is coming to an end. As a final note, the hosts organize a networking session, during which I manage to have a private conversation with the Danish water ambassador in Italy, Liam.

'Our meetings with international water professionals work just like the news on TV. We begin by sharing information, and then we gradually introduce the commercials'. Liam has just introduced himself to me as the Danish water ambassador at the Royal Danish Embassy in Rome. The information that he refers to consists of Danish legal, technical, and environmental conditions for water management and how specific Danish water utilities address water management challenges in practice. This sharing of information takes place either in Denmark, at water technology companies or water utilities, during

[7] This chapter is adapted from the scientific article of the same name (Jessen, Forthcoming), which is currently in review.

visits of international delegations of water professionals, or during 'fact-finding' trips, where the water ambassadors visit European water utilities. 'By now', Liam continues, 'you already see how the participants' shoulders drop and their faces start to relax, as they realize that we are not just another salesperson. We do not come with a product to sell. We come as colleagues offering new concepts and relations'. This is the moment where, according to Liam, the 'commercials' enter the picture: 'Finally, we have the Danish companies join the conversation, but we don't want them to just talk about their products. We want them to explain how they have helped specific Danish water utility companies achieve their results so that they can become part of our narrative. Like this, we build a trustworthy and collective story that explains why we are so good at managing water in Denmark'. Liam refers to this as a 'soft sell approach'. 'The sharing of good and bad experiences between colleagues', he goes on, 'makes both parties lower their guards so that we can generate genuine interest for how Danish solutions can help improve other water sectors. This is a premise for any kind of export. (…) But believe me, we might reach out as a colleague and not as a salesperson but, at the end of the day, this is all about hardcore selling – in disguise'. I was intrigued. What does this 'disguise' entail? How does the 'hardcore selling' wrapped up in soft national narratives that Liam refers to peculiarly entwine with transnational relation-building and water management?

As digital water technologies are increasingly perceived to pose potential solutions to global commercial, climatic, and water challenges, I turn to a specific kind of sociality, namely the kinds of relations and imaginaries that are stored in – and storied through – digital water technologies. In this article, I explore how water management technologies become scalable and commoditized through storytelling in a Danish context. I engage with this

form of storytelling as a 'digitally enabled sociality' and argue that perceiving the uptake of digital water technologies through 'water diplomacy' – the art of crafting and managing water narratives trans-nationally for export purposes – allows us to engage ethnographically with how current and future waterscapes are impacted by the digitalization of water management.

I begin by presenting my methodology and contribution. Hereafter, I offer a critical ethnographic analysis of the social life and politics of Danish water management. I do so by framing it through the entwined narratives of crisis and exceptionalism, and the promises of green transition, digitalization and scalability that currently flourish in the Danish water sector. Then, I discuss how specific water narratives are strategically crafted by Danish authorities in concert with private and public actors, and how they take material form for commercial purposes. Finally, I provide an ethnographic account of how the logics of scale and scalability that are embedded in these narratives emerge and gain agency in practice as a form of 'Water Diplomacy' through the work of the water ambassadors. As the Danish water sector increasingly turns its gaze towards new 'markets', such as the Italian, offering not digital technologies per se, but expertise and new relations, I aim to show how these forms of sociality are made possible through imaginaries of digitalization, and how they contribute to the blurring of different layers of boundaries between public (institutions, rights) and private (companies, assets) in the Danish Welfare State.

Methodology and Contribution

This article is a result of 12 months of intermittent ethnographic fieldwork between January 2022 and September 2023 conducted in the Danish water sector. It draws on detailed ethnographic fieldnotes from participant

observation gathered among water professionals in Denmark and Italy, during diplomatic trips, at conferences, and in their daily work at water utility companies, along with countless semi-structured interviews and casual conversations. These actors include water utility employees, engineers with different kinds of expertise, technology and service providers, as well as the water ambassadors, whose function is made anonymous through the composite figure of Liam, whom I refer to as the water ambassador at the Danish Embassy in Rome.

In a sense, this is a multi-sited analysis (Marcus, 1995), as it looks at the connections between Danish and Italian waterscapes through the lens of storytelling. Notably, the Danish water sector is not particularly geographically bounded (Candea, 2007). It expands beyond the national borders of Denmark in multiple ways through commercial and professional relations. For this article, I have focused on its relation to Italy, as a promising and emerging 'market' for Danish water technologies. My fieldwork has thus brought me back and forth between Italy and Denmark, as I follow Liam's diplomatic work. For this reason, this article is also about ways of relating between individuals and institutions (Bruun et al., 2011). This form of sociality is made of transnational connections, storying practices, and articulations between Danish and Italian water professionals. All these iterations are part of a single site – the Danish water sector.

In dialogue with the theme of this Special Issue, my focus shifts from digital technologies to the kinds of transnational exchanges and relations that emerge *in light of* the digitalization of the Danish water sector. Through storytelling, my aim is not only to highlight how practices of export-as-soft-sell are inherently interwoven in processes of digitalization. I aim to explore also the

implicit repercussions that water diplomacy has on the Danish water sector as a *digitally enabled sociality*.

With increasing challenges related to climate change, expanding urbanisation, and groundwater pollution, the question of how to manage the finite global water supply differently – in a more equitable, efficient, and sustainable manner – is ever-more pressing (Paerregaard & Andersen, 2019; Strang, 2021). As I take up a perspective on forms of storying water, with this article I build on an anthropological scholarship on water (infrastructures) that acknowledges how practices of knowing and managing water – as well as the infrastructures that sustain them – are both deep, complex, and extend way into the diverse realms of the social (Anand, 2017; Andersen, Astrid Oberborbeck, 2018; Hastrup, K. & Hastrup, 2015b; Orlove & Caton, 2010; Strang, 2004). This article also builds on previous studies of storying and narratives as being more than ways of communicating and knowing (water), but also an ethnographic entry point into the social production of (Digital Water) futures (Bruner, 1991; Hirsch & Stewart, 2005; Ochs & Capps, 1996).

Furthermore, I attend, ethnographically, to water diplomacy with an ethnographic sensibility to notions of *scale* and *scaling*. Within anthropology, scale has traditionally been connected to multi-sited ethnographic studies of large-scale, global(ized) phenomena. As laid out by Marcus and Fischer (1986), a challenge for multi-sited ethnography is to find a way to embed richly described local cultural worlds in larger impersonal systems of political economy (Marcus & Fischer, 1986: 77). Here, scale refers to the advantages of shifting ethnographic attention between different levels analysis – often categorized as micro-meso-macro (Fortun, 2009) – by using empirical work at the local level to understand (and challenge?) macro-frameworks and

discourses, such as capitalism and globalization, in ways that represent and give voice to the complexity and diversity of its local nuances (ibid. 99; see also Barth, 1978). Rather than seeing scales as predetermined, anthropologist Anna L. Tsing (2000) encourages us to 'pay close attention to *ideologies* of scale, that is, cultural claims about locality, regionality and globality' and, in a similar vein, to 'track the rhetoric of scale as well as contests over what will count as relevant scales' (Tsing, 2000: 347). Looking at scale-making as social and material processes and cultural commitments through which localities or globalities come, tentatively, into being (ibid. 348), Tsing approaches scale and scaling as anything but neutral. On the contrary, she argues, scales are 'claimed and contested in cultural and political projects' (Tsing, 2005: 58), making scale a device to study and understand power differences and distribution in global capitalist societies. Building on these approaches to scale and scaling, anthropologist David Ribes has devised what he refers to as an 'ethnography of scaling' (Ribes, 2014). Ribes suggests a way for ethnographers to investigate large-scale projects by focusing 'on the work of actors as they go about knowing and managing that large-scale object' (Ribes, 2014: 158). This can be done, he argues, through a sustained ethnographic sensibility to *scalar devices*: 'an assembly of techniques, tools and representational conventions that are used to know and manage scale'.

In this article, I engage ethnographically with two forms of scalar devices, namely the Danish Export Strategy for Water (The Danish Government, 2021), and the work of the Danish water ambassadors. I aim to reveal how Danish water narratives about the digitalization of water management shape new configurations of the social in terms of knowledge exchanges, international relations, and hierarchies – and how these, in turn, impact what it means to do diplomacy and export in Denmark and beyond. I will pause

this discussion on scale here for now, as I proceed by situating this study geographically in the Danish Water Sector and as I contextualize by situating the concept of Digital Water within a theoretical framework.

The Danish Water Sector

The Danish water sector consists of about 300 private companies, public water and wastewater utilities, consultants, interest organisations, cluster organisations, universities, research, and innovation centres, and approximately 2600 waterworks and 700 wastewater treatment plants. With drinking water losses averaging well below the global and European average, and energy neutrality being a major focus for more than 20 years, Denmark is often referred to as a global frontrunner in water technology development. This narrative is, as I will unfold later, heavily nurtured by the Danish Government and local interest organisations (DANVA, 2022; The Danish Government, 2021). According to many of my interlocutors, this position is historically rooted in the visions and strict environmental and economic regulations that were introduced in Denmark during the 1980s and 1990s. These initiatives compelled Danish water and wastewater utilities to test and develop an array of new environmental technologies and processes to comply with the new directives. An often-mentioned example is the Water Tax Act (1993), with which Denmark became the first country in the world to impose a tax on water utilities for water loss in the public drinking water network. The Water Tax Act offers an example of how public policies encouraged Danish water utilities to engage in public-private partnerships with local water technology companies to reduce Denmark's water loss to the current average of 7%, which is well below the global average. The technologies that were developed by these partnerships also helped Danish water companies

enter the international market with solutions to prevent precious water from being wasted from leaky pipes around the globe. This can be perceived as reflecting an influx of neoliberal ideas about market governance and efficiency that has gradually trickled down the Danish Welfare State since the 1990s (Pedersen, O. K., 2011).

Often addressed as a New Public Management-inspired reform (Staunstrup et al., 2023: 14), a Danish Water Sector Reform Act (2009) was passed in 2009. It came out of the at the time ruling government's policy on privatization and optimization of public institutions, including water utilities which, until then, had been public institutions managed by local authorities. With the new Act, most Danish water utilities became (and still are today) quasi-private, non-profit stock-based companies owned by the municipality, but with the autonomy to make their own strategic and commercial decisions independently from the municipality's. However, Danish water and wastewater utilities are exempt from free market rules. They are natural monopolies, which entails that local households and private enterprises cannot choose their supplier freely. Therefore, to ensure high water standards for the citizens and companies, and to prevent water prices from growing artificially high, the Act imposes yearly financial regulations on the utilities to create conditions like those in competitive markets artificially.

These regulations are based on a so-called 'break-even' principle, which compels Danish water utility companies to an annual net-zero income, while also sustaining a 2% annual revenue reduction from their customers' water tariffs. This is seen as an incentive to stimulate the development of innovative solutions to optimize existing operations in terms of water and energy efficiency and, by extension, reduce operating costs. Therefore, water utility

companies are permitted, in addition to their water and wastewater activities, to sell services, residues and energy with a certain profit, provided that these activities are closely linked to their primary activity (DANVA, 2022: 10). In practice, the Danish Water Sector Reform Act compels Danish water utilities to invest heavily in 'innovative development, demonstration, and export of Danish water technologies' (Water Sector Reform Act, 2009: §1, Author's translation) to meet its economic requirements, and thus continue carrying out their primary activity, namely providing quality drinking- and wastewater management in Denmark.

This could be perceived as a process of depoliticization, considering the semi-privatization of water management and its economic and strategic separation from municipal agendas, as many of my interlocutors claim. However, as I will argue, this apparent detachment from public governance has contributed to the rise of a new kind of politics that effectively blurs boundaries between water management as a public and private enterprise in Denmark and beyond, through what I refer to as 'Water Diplomacy'. I will return to this point later. For now, let me simply emphasize how Danish water policies have historically paved the way not only for ongoing processes of privatization and effectivization of water management in Denmark. They have also compelled local water utilities to engage in intimate and intricate collaborations between private companies, the state, and public institutions in and beyond Denmark as a premise for their economic sustainability.

Situating Water Diplomacy

The concept of 'Water Diplomacy' has been increasingly present in academic and policy circles since the early 2010s. It builds on an understanding of water as a vital yet diminishing resource (Grech-Madin et al., 2018: 101) that is

increasingly disputed and politicized. This perception of water was formally institutionalized in the 1990s when international water policies became an integrated part of the discourse around sustainable development (Bisht & Ahmed, 2021: 446). While arguably still lacking a clear definition, Water Diplomacy is broadly seen as a sub-field of diplomacy, understood as the art of building up and managing interpersonal relations among international actors to 'communicate and collaborate with as well as influence' foreign governments and stakeholders (Keskinen et al., 2021: 2). It deals with political disputes and concerns around transnational watersheds in the intersection of water-related knowhow and political cooperation mechanisms (ibid. 5). With only a few exceptions (see Bisht & Ahmed, 2021), scholarly research on Water Diplomacy stems mostly from natural and political sciences, focusing either on its potential policy and environmental implications or on the discourses around it.

The way that I explore water diplomacy in this article diverges slightly from the abovementioned. Firstly, it sheds light on the transnational storying of the 'Danish Narrative' performed by the water ambassadors as a form of Water Diplomacy in practice. My interest in the diplomatic efforts of the Danish water ambassadors lies not only in their relation-building qualities but also in the way they influence national imaginaries of self (Ochs & Capps, 1996) and identification (Jenkins, 1997) through storytelling. The telling of stories, as Nikhil Anand (Anand, 2017: viii) reminds us, 'is always a political act'. Secondly, and importantly, by exploring the intersection between Water Diplomacy and ideas of scaling water technologies, I aim to expand both what it means to do diplomacy *and* export in the management of current and future water flows. Having positioned this study thus, let us return to my first meeting with Liam, the Danish Water Ambassador.

Selling stories, softly

The conversation that opens this article originates from the launch of the 'Water Technology Advisory Europe' (WTA EU) at the beginning of 2022. This is where I first met Liam, the Danish water ambassador in Rome. At the time, I was conducting ethnographic fieldwork for my doctoral thesis about the emergence of ideas and practices of the digitalization and export of water management solutions that currently saturate Danish waterscapes. I quickly became interested in the WTA EU, because it seemed not only to gather some of the key actors of the Danish water sector around new export practices but also to direct their agency towards what they addressed at the launch as 'new markets for Danish water solutions' in a subtle, yet quite resolute manner.

The WTA EU is a Danish outreach programme designed to promote the sharing of Danish know-how and experiences with advanced water technologies with European water utilities and authorities through the figure of the 'water ambassador'. The water ambassadors do not, however, serve a purely informative or diplomatic purpose. They have a commercial function too. The WTA EU is specifically established to contribute to the Danish Government's ambition of doubling the revenue from exporting Danish water technologies by 2030 while addressing global water-related challenges with Danish solutions (The Danish Government, 2021). Reflecting this aim, the administration of the WTA EU is formally rooted in The Trade Council at The Ministry of Foreign Affairs of Denmark, with partners including a handful of the biggest Danish public water utilities, the Danish Environmental Protection Agency, and leading technology and service providers.

At the launch of the initiative, I was puzzled by how the WTA EU, it seemed to me, pulled together notions of transnational relation-building, export, and

local public services in novel ways, projecting the Danish water sector into a sort of politico-commercial international arena. The five water ambassadors who were gathered at the launch emphasised how they would contribute to enhancing and streamlining the promotion of Danish water technologies in Europe by taking a 'local approach and matching Danish competence where it fits'. In practice, they argued, this would entail a targeted effort towards fostering new partnerships and mutual learning between European and Danish water professionals for the ultimate purpose of export. They called this a 'soft sell' approach. Not exactly sale, nor diplomacy, the work of the water ambassadors consists in nurturing relations between European water utilities and Danish water technology companies with the silent ambition of, with time, carving out a market for Danish water technologies where none currently exist. This, as Liam would explain to me, happens not by selling technologies, but by selling a particular *narrative*.

The work of the water ambassadors is perhaps best understood in relation to the recent announcement of a new 'Export Strategy for Water'. The Strategy was published by the Danish Ministry of Foreign Affairs in collaboration with the Ministry of Industry, Business and Financial Affairs, and the Ministry of Environment just a few months before the launch of the WTA EU (The Danish Government, 2021). The Strategy builds on the belief that, instead of sending actual salespersons, the Danish water sector will benefit (and profit) more by having Danish water professionals contribute to craft, sustain, and spread what it addresses as the 'Danish Narrative'. This Narrative is not Danish in the sense that it pertains to Denmark and the Danish water sector alone. On the contrary, it taps into local and global trends and concerns alike. It is meant to unify Danish export activities within one overarching narrative that stages Danish water management solutions for internationally.

In what follows, I engage with the making of the 'Danish narrative' by attending to three Strategic white papers recently published by the Danish Government concerning water export, digitalization, and 'global climate change' (The Danish Government, 2020; 2021; 2022). I juxtapose these strategic narratives with the work of propagating the Danish Narrative that is carried out by the Danish water ambassador in practice. As we shall see, this work does not directly entail the selling of water technologies, but rather the fabrication, sustaining, and – as I argue – the scaling of the Danish Narrative through transnational encounters, moments of negotiation, interpretation, and exchange between Danish and European water professionals for export. I explore this phenomenon as a form of Water Diplomacy.

Climate action, digitalization, and exceptionalism: Strategizing story

The Export Strategy for Water opens by elucidating how the lack of clean drinking water, untreated wastewater, and the increasing threat of droughts and floods, are some of the biggest challenges for global livelihoods and economies. This causes, it claims, a growing demand for smart and sustainable water solutions (The Danish Government, 2021). Indeed, pressed by climate change, pollution, increasing urbanization, and ageing infrastructure, waterways and water supply systems across the globe are widely regarded to be in a state of unprecedented crisis (Cosgrove & Rijsberman, 2000; Hastrup, K. & Hastrup, 2015b; Linton, 2010). As it permeates global waterscapes, crisis is a crucial element in the storying of water in Denmark too, as a call for action in a race to preserve and protect it. Although regrettably, this seems to provide the basis and incentive not only to explore novel ways of imagining water but also of managing it otherwise.

In Denmark, particularly since the economic and environmental regulations of the 1980s and 1990s, digital infrastructures such as complex monitoring and surveillance systems have played a central role in optimizing and automating many aspects of the control of water flows, pressure, and distribution. However, the notion of digital, or smart water technologies has only recently entered the Danish water sector. 'Smart' is an idiom that is used among my interlocutors to describe the uptake and progressive integration of (ideas of) automated and predictive technologies within traditional water supply systems[8]. These digital water technologies are based on large quantities of digital datasets from smart metering systems, satellite imaging, remote sensing solutions, machine learning, and AI-empowered predictions. Aligned with the vision of the international water milieu (Garrido-Baserba et al., 2020; IWA, 2019), digital technologies and infrastructures are widely perceived among Danish water professionals to carry the promise (Anand et al., 2018) of optimizing global water flows and to enable informed decision-making under increasingly unruly climatic conditions, based on real-time interoperable water data (CALL Copenhagen, 2018; Mikkelsen et al., 2019). These systems are designed to 'fix' current challenges in water management such as leaking waters (and profits), droughts, and ageing infrastructures, while responding to current and future climatic challenges and staging novel avenues for global export endeavours (Andersen, Astrid Oberborbeck & Jessen, 2023).

[8]See (Jessen et al., 2023b) for a discussion of how digital water technologies become enmeshed with situated knowledges, traditional practices, and socio-technical stratifications that mess with what 'smart' means in practice, and for whom.

The Export Strategy elaborates how the Danish water sector has both an ambition and obligation to contribute to solving global climate challenges by scaling these digital technologies. This claim to action is sustained by asserting that Denmark holds a strong position 'to provide intelligent and sustainable solutions' to the world through its leading 'technology manufacturers, utilities, and advisers within water technology solutions' (The Danish Government, 2021: 4). These narratives go hand in hand with what the former ruling Government and authorities addressed as Denmark's historically high ambitions within the green transition agenda, which encompass taking global leadership on climate action (The Danish Government, 2020).

The Export Strategy for Water outlines several pathways to 'gather, prioritise, and strengthen the expansion of Danish water solutions' by taking 'advantage of the possibilities in foreign markets' (The Danish Government, 2021: 4, 8). One of these avenues appears to take shape around processes of digitalization as catalysts for export and development: 'If Danish water companies and Denmark's efforts for better water management and a better aquatic environment are to continue to be at the forefront, Denmark must become better at utilising the new opportunities that the digital change in technology and society provides' (The Danish Government, 2021: 35). Being 'one of the world's most digitalised countries', so claims the then ruling Danish Government (2022: 3) in a recently published Strategy for digitalization, 'Denmark is in a strong position to seize the digital opportunities' (The Danish Government, 2022: 3) that are believed to provide solutions for the current global climatic and water crises. Furthermore, stressing how climate change, just like water, 'knows no municipal or national boundaries', the Government's digital strategy is directed towards all parts of society,

encouraging a concerted effort of collaborations 'across the public sector, private sector players and research communities to create value in our digital, green efforts' (ibid. 40).

Altogether, these strategies reflect a tendency of the Danish Welfare State to increasingly mobilize public and private organisations to compete for global market opportunities (Pedersen, O. K., 2011). As the Export Strategy for Water reveals, the Danish storying of water intersects with politics of global climate action *as* market expansion by means of digitalization. Digitalization, it seems, promises scalability (Seaver, 2021).

Scaling narratives: The Water Ambassadors

The Export Strategy for water explicitly mentions storytelling as a key intervention in the effort of 'branding Danish solutions, products, and models' (The Danish Government, 2021: 28). Beyond portraying Danish companies as leading players in a global market, and on a quest to help other countries become more efficient and sustainable, we have seen how the Strategy also engages water specialists ranging from private actors, water technology providers from private companies, universities, Danish water authorities and public water utilities in nurturing a unified and homogeneous narrative of Danish exceptionalism across different sectors and, by extension, of Denmark as a country (Bruun, 2018). But, by depicting the condition of the Danish water sector as internationally desirable, narratives of Danish exceptionalism are also imagined to function, through careful orchestration and diplomatic work, as a blueprint for the betterment of global water flows. I have shown how digitalization plays a key role here, allowing ideas of scale and scalability to permeate Danish water narratives through the potential interconnectivity

and adaptability of digital technologies for water management across different geographical contexts.

Anthropologist Anna Lowenhaupt Tsing (2005; 2012; 2013b) has written extensively and critically about the work of naturalizing ideas of expansion in capitalist pursuits of (up)scalability. By studying e.g. how wild Matsutake mushrooms are foraged in the Pacific Northwest and then turned into commodities through various iterations of assessment and sorting practices, Tsing exemplifies how commodity chain capitalism produces scalable commodities through nonscalable practices (Tsing, 2013b). By theorizing on the notion of 'non-scalability', Tsing (2012) also emphasizes how the practice of scaling relies on 'articulations with nonscalable forms even as it denies or erases them' (ibid. 506). Accordingly, I argue that the storying practices and forms of Water Diplomacy performed by the Danish water ambassador is a nonscalable process which enables the scalability of Danish water solutions. Albeit being an inherently contextual, relative, and social form of relating, or 'care' (Seaver, 2021), Danish water narratives invisibly allow for the commodification of digital water technologies. Notably, however, what is being scaled in the first place are not digital water technologies per se, but the Danish Narrative itself.

In practice, the transnational storying of the Danish narrative is primarily carried out by the work of the water ambassadors, whose short-term task consists of creating new 'water alliances' with local authorities in specifically targeted countries to share and propagate knowledge about Danish water governance and solutions. On a long-term perspective, though, these initiatives are expected to support the commercial access of Danish water technology companies to new 'markets'. The relation-building work of the

water ambassadors is pivotal for the success of these alliances, as it brings Danish companies closer to local authorities and potential customers through a combination of the diplomatic efforts that have been initiated by the Danish Ministry of Foreign Affairs, the local socio-technical knowledge of the water ambassador, and the commercial interests of specific Danish companies (The Danish Government, 2021: 23).

One of the targeted countries, or 'markets', is Italy, which, as already mentioned, suffers from ageing infrastructure and a heavy water loss of around 40% from its public piping system. The Export Strategy estimates that Italy will be one of the European countries to invest most heavily in renovating its water infrastructure in the coming years, making it a new potential market for Danish water technologies. In what follows, I will illustrate how Water Diplomacy takes place in practice through an ethnographic account of one such water alliance between Danish and Italian water professionals.

Doing Water Diplomacy

It is a hot May morning in Northern Italy, close to the city of Reggio Emilia. Liam and I are on one of his fact-finding trips at a local water utility, where he gathers information about local water management practices to match them with potential Danish water technologies. While leaving our hotel earlier that day, Liam told me about how he had set up the meeting:

> *When I started working for the Danish Embassy in Rome, I began to follow the ambassador – you know, the actual Danish ambassador in Italy – in his visits around the country. During these visits, he would also invite local water utility companies to*

meet with him. That is how I gained access to utilities with which Danish companies struggle to gain contact; by using the respect that Italians show for the authority represented by the ambassador. Another thing that helps, though, is the fact that I represent Denmark. Most Italians know Denmark as a country where things just work in a way that they may envy or strive for. So, I mean, it is easy to be a Dane and visit these utilities, because even though it is not my merit, in their eyes I represent something good. So, they will listen to me and that helps me build up commercial relations.

At the utility, we were greeted by a handful of local engineers who guided us to an office where they had set up a slideshow. The atmosphere was quite formal, and the engineers quickly started presenting the technicalities of the utility where they work which, I learned, is technically advanced compared to Italian standards. Serving approximately 2.5 million inhabitants, the local utility company consist of a conglomeration of several utilities which were recently brought together, each with its own story and way of managing the local supply system. This has brought several challenges for the utility company. Some stem from the geographical context due to the inaccessibility of some of the drinking water pipes located in mountainous areas. Other challenges relate to the nature of the serviced urban areas, which are closely inhabited, and require wastewater treatment plants to deal with the reduction of odours and hydrogen sulphide (H_2S). Finally, some challenges concern eco-cultural and political matters. As the engineers explain, the treated wastewater from some plants is *de facto* the main source of water for some local rivers, meaning that processes of centralising wastewater treatment would cause them to dry up.

Along the way, Liam draws parallels to exemplary solutions to similar challenges in a Danish context, such as how the Aarhus ReWater project (Aarhus Vand, 2023) which adopts advanced Danish H_2S sensors, and how the LEAKman collaboration (NIRAS, 2021) has helped dramatically reduce water losses in Denmark to the current average of 7%. The engineers look at each other and, with a grin, observe that such numbers would be science fiction in Italy, where they deal with 20% water losses at best. Looking perplexed at Liam, they ask: 'Why is it, exactly, that the Danish Embassy wants to visit us?' 'It is a priority for the Danish Government', he answers, 'to use Danish water expertise to develop a strong relation with Italy in the water sector. We want to hear about your challenges and solutions and offer our experience in exchange. Therefore, we invite you to come to Denmark to see how we do things up there'.

About two months later, I met with Liam again. This time at Aarhus Vand, a Danish water utility company. With him are two delegations of Italian and German water professionals (including the Italian engineers that I met earlier that year). The day starts with a round of presentations and expectations for the day, where most participants highlight their 'curiosity to discover something about digitalization', and expectations 'to learn about water loss reduction from Denmark'. Following, a representative from the Danish Ministry of the Environment gives a presentation about their policy work for the Danish water sector. Then the local hosts at Aarhus Vand present their future ambitions, strategies, and concrete projects regarding structured and digital water loss monitoring. Specifically, they show how Aarhus Vand identifies leaks through a data-driven leakage detection system and explicate how those systems combine technologies and software from different Danish companies to achieve the best results. The day concludes with an excursion

at the current wastewater treatment plant at Aarhus Vand which is estimated to become one of the most energy efficient in the world: Aarhus ReWater, and at a demonstration facility for water leakage detection, which is part of the Danish LEAKman collaboration.

Aarhus Rewater is a project through which Aarhus Vand aims at building what they claim to be the world's most resource-efficient wastewater treatment plant by 2028. According to Aarhus Vand, the new plant will help decouple the increasing amounts of treated water and waste of the growing city from its environmental pressure. The underlying philosophy entails perceiving wastewater as a resource that can be recovered and utilized. The plan shall also serve as an international knowledge hub for new technologies to continuously 'develop and capitalize' on new ideas (Aarhus Vand, 2023). These visions have gained Aarhus Rewater an international reputation as one of the 'virtuous examples' of Danish water management, attracting visiting delegations from all over the world, as it aims to develop and utilize some of the finest and most innovative technologies in the Danish water sector.

The 'LEAKman' project combines, instead, an ecology of water technologies produced by different Danish companies spanning from intelligent pump control, smart pressure management and leakage detectors. Altogether, these technologies are argued to deliver a 'unique Danish solution to stop global water loss' (NIRAS, 2021). The project is developed by nine Danish partners, including technology providers, consultants, water utilities and a technical university that combines Danish 'knowledge and technologies' to provide 'a state-of-the-art solution for leakage control', which is 'customisable to any utility' (ibid.).

Danish state-of-the-art projects and solutions such as Aarhus ReWater and LEAKman serve as cornerstones of a narrative about local solutions to global water-related challenges made in Denmark, which is carefully made actionable and propagated transnationally by the Danish water ambassadors to enhance the international appeal of Danish technologies. Whilst they do not directly advocate for Danish water technology, these projects serve the purpose of legitimizing the Danish Narrative in the eyes of potential international delegations. Within this framework, water utility companies such as Aarhus Vand, serve not only as public service providers. As living laboratories for the testing and development of cutting-edge Danish technologies, they act, also, as avenues to showcase novel Danish water technologies to the world.

Conclusion: Situating Stories

One can easily imagine why Danish state-of-the-art projects such as LEAKman and Aarhus ReWater are equally referred to by Italian utility operators as a desirable future and as science fiction, cementing Denmark as a stronghold for ideal water management solutions in local imaginaries. As Liam explains, visiting Denmark makes an impression on Italian delegations: 'What works is not only visiting the major Danish water technology companies and utilities. Visiting Denmark for some time and seeing how everything just seems to work substantiates a Danish Narrative of high standards'. Nevertheless, while the Danish Narrative tends to generate a coherent and organic picture of the 'smartness' of the Danish water sector as a homogeneous whole and, by extension, of Denmark as a country permeated by seamlessly working cutting-edge technology, this is quite far from reality (see Jessen et al., 2023b). In fact, what makes the visits of foreign delegations

an effective part of the soft sell strategies employed by the water ambassadors, is that Danish water and wastewater utility plants function, very much like the Italian. This allows the water ambassador to 'disguise hardcore selling' as 'soft' relation-building and knowledge sharing. The work of the water ambassador consists, in other words in meticulously translating a story of exceptionalism into one that is not only relatable and desirable for the visiting delegations, but also within reasonable reach. The scalability of the Danish Narrative depends, thus, on a form of situated work, which is inherently nonscalable (Tsing, 2012).

During my fieldwork at the water utility near Reggio Emilia, I became aware of how there are, embedded in water management practices, various adjacent, albeit often also divergent stories of technologies, ecologies, politics, and controversies that tell something not only of past but also of current and future desires and contingencies of local and international actors in the context of uncertain climate futures. Looking at water management and control through different forms of storying, and at the art of crafting and managing stories for commercial purposes as practices of Water Diplomacy, this article shows how the uptake, and strategic storying of digital technologies in the Danish water sector becomes part of a grand Danish Narrative that enables new forms of sociality and diplomacy.

I have argued that the transnational relations, imaginaries, articulations, and exchanges that are embedded in formal narratives, such as the Danish Export Strategy for water, and enacted by the water ambassadors, are made scalable by the ideas of global connectivity, commensurability, and effectivization that reside in digital technologies. Thus, I suggest that Water Diplomacy, a sort of digitally enabled sociality, represents an ethnographic vantage point into the

current and future of the Danish water sector. Reflecting an increasingly neoliberal and internationally competitive Danish Welfare State (Pedersen, O. K., 2011), Danish water management stretches beyond local and public services, encompassing commercial agendas and engaging public water utilities as avenues for global commercial ambitions through the diplomatic work of the water ambassador.

Water Diplomacy blurs conventional boundaries between private and public spheres in the Danish water sector, expanding both what it means to do diplomacy and export. As ideas of digitalization intersect with promises of commercial scalability, the betterment of water management, and environmental sustainability, concepts like Water Diplomacy suggest the necessity for further explorations of alternative vocabularies that complicate binaries such as private and public, diplomacy and export, and commons and commodities, which do not seem to sufficiently describe the complexity of their (digital) sociality.

Wrapping Up

In this chapter, and through the article that it builds upon, I show how the primary concern of most Danish Digital Water pioneers seems not to be how to better water flows and services locally, but rather how to make their global scaling profitable. I have shown that the figure of the Danish water ambassador, a materialization of Digital Water in the making, paves the ground for the scaling and export of Danish digital water solutions by identifying new commercial opportunities and crafting new international relations by means of storytelling. I refer to this process as 'Water Diplomacy'. Furthermore, I have shown how the strategic storying of Danish water narratives performed by the water ambassador allows Digital Water to

become scalable, commodified, and exported. Through Water Diplomacy, the water ambassadors mobilize ideas of diplomacy and export and set them productively in tension. Engaging with this tension ethnographically, I have argued that the water ambassador enacts Digital Water, through storytelling, as a model to sustain the financial future of the Danish Welfare State. In other words, with this chapter, I have described how Digital Water promises new national economic export endeavours and to solve global climate and water challenges by setting ideas of diplomacy and export in tension.

In the next chapter, I will shift my scale of attention (Hastrup, K., 2013) from a national and international scale to a local perspective. In what follows, I zoom in on how Digital Water – and some of the technologies and solutions that are being storied and internationally scaled through Water Diplomacy – affect local water management, sensing, and sensemaking practices in a hands-on way among water utility employees. This chapter will bring you close to the minutiae of water management and water leakage detection practices in Lemvig Water and compare them with those of other Danish water utility companies. By setting these two scales of attention – the global promises and the practical, local implications of Digital Water – in tension, I hope to convey a deeper appreciation of what is at stake with the digitalization of water in Denmark.

Chapter 6. Making Sense of (Digital) Water

The Danish Water Conference

I was first contacted by one of WADE's consultants, Peter, after my first period of ethnographic fieldwork at Lemvig Water, in August 2021. 'WADE Consulting' is a Danish consultancy company specializing in engineering and the built environment. Peter reached out to me on the business and employment-focused social media platform 'LinkedIn' after I had shared a local newspaper article about my fieldwork in Lemvig. He was interested in what he called the 'human factor' in the digital transition of Danish water management:

> *Far too many decisions about water management are currently taken based on human assumptions, memory, and gut feelings. Basing important decisions regarding critical infrastructures, such as water supply, on those assumptions is a foundation which is far too insecure. However, digital water data is also often too faulty and fragmented to be relied on. I think the water sector needs to strike a better balance between automation [ed. adoption of data-driven tools, AI, and machine learning] and human decision-making in the future. To do this, we need to improve and systematize both the artificial and the human factors in decision-making.*

With the 'human factor' and 'gut feelings', Peter referred to a widespread stance among Digital Water pioneers, which regards 'humans' and 'culture', as some of the biggest barriers to implementing digital water solutions in practice. 'Gut feeling' is often used to describe situations when water utility

operators make decisions about water and infrastructure management based on their experience, rather than quantitative data. Digital Water pioneers often refer to gut feelings in contrast to digital data-based decision-making, emphasizing how critical decisions (in economic and sanitary terms) are often taken based on the memory, assumptions, and sensations of experienced employees because this is the only information available. Professionals like Peter argue that Digital Water technologies offer an alternative to such a 'weak' foundation for current decision-making through digital sensing technologies, generative AI, machine learning, and the hard, 'objective' data they produce. During my fieldwork, I often heard – at business events and during interviews with Digital Water pioneers – 'the human factor' and 'culture' articulated as the areas with the biggest potential for innovation in the digitalization of water management in Denmark. This view on human-technology interactions has roots in human factors studies (Salvendy, 2012), a variety of which perceive human abilities and knowledge (or lack of the same) as central limiting factors for the proper functioning and implementation of new technologies, designs, or tools. Peter's approach was, in my eyes, a constructive and explorative way of perceiving human-data relations in water management, where the potential for improvement could be found in the relation between human sensing and quantitative data, not either one or the other. Furthermore, he was interested in learning new ways to advise the Danish water sector about its future which, in his eyes, is going to be increasingly digital. Did the term 'human factor' open a door into a space in which Peter and I could collaborate?

In this chapter, I argue that the 'smartness' of digital water systems is situated (Haraway, 1988) and so are the kinds of knowledges and forms of expertise through which they are operated by local water utility employees. I suggest

that water management is ‘sensuous’ work (Howes, 2009; Pink, 2021) as well as it is ‘calculative’ (Callon, 1998; von Schnitzler, 2008) and I show how experimenting with and exploring these two perspectives through ‘para-site’ forms of ethnography (Marcus, 2022) elicits surprising and fruitful insights that bring those perspectives closer to each other, bringing us closer to understanding what ‘smart’ Digital Water management means in practice.

When describing water management as ‘sensuous’ work, I draw on David Howes (2011). Howes claims that ‘sensation’ in anthropology plays on ‘the double meaning of the word “sense”: it can refer to sensation and/or signification, to feeling and/or meaning’ (Howes, 2011: 94). In this sense, beyond referring to water operators’ and digital sensing technologies’ sensory perception, I attend to sense and sensation as the affective modes through which sensing practices relate to experiential forms of sensemaking.

When referring, instead, to water management as ‘calculative’ work, I draw on the work of political economy and political ecology scholars who have focused on how the introduction of technologies of quantification result in, enable, and lead to changing water politics. Anita von Schnitzler (2008), for instance, convincingly shows how the massive installation of prepaid water meters in townships around Johannesburg in the decades after apartheid not only led to the reshaping of marginal residents’ access to and everyday engagement with water but also – through the creation of a ‘calculative rationality’ – to the formation of new political subjectivities (von Schnitzler, 2008: 901-902). One of von Schnitzler’s central points on which I draw here is that the digitalization, quantification, and marketization of water solutions rests on and reinforces such calculative rationality, or ‘spaces of calculability’ (Callon, 1998), which are made possible through the increasing uptake of

digital ‘tools of measurement’ (Callon 1988 in von Schnitzler, 2008: 902), such as digital water sensors. As I touched upon earlier, the ‘human factor’ and its qualitative, sensuous character is often set up as a counterpart to the supposed reliability of machinic forms of quantitative and data-based ‘calculative rationality’ in contemporary Digital Water discourse. However, with Peter, I seemed to have found a promising ‘epistemic partner’ (Holmes & Marcus, 2008) in exploring ways of thinking this relation otherwise.

I open this chapter by describing the beginning of my collaboration with Peter and his colleagues at WADE, which started after my presentation at the 2022 Danish Water Conference. Thereafter, I continue to dwell on notions of ‘culture’, ‘gut feelings’ and ‘the human factor’. I do so through a narrative, playful, speculative, and critical juxtaposition of Digital Water pioneers’ perception of digital water data, and water utility operators’ sensing and sensemaking practices. With these stories I wish to epitomize how different forms of human and machinic sensing, experiencing, and knowing meet, stand in tension, collaborate in (un)productive ways, clash and on some occasions enmesh in water management practices. I continue by discussing how digital water management takes place within a more-than-human ecology of sensing and sensemaking practices.

In the second part of the chapter, I shall return to the aftermath of my presentation at the Danish Water Conference. From there, I shift my attention to the interdisciplinary, cross-sectorial, and collaborative workshop that Peter, my SWIft colleagues, and I planned on ‘Human and Artificial Intelligence in Future Water Systems’. Here, I offer a reflection on how my ethnography moved from critical *studies of* to collaborative (and not un-critical) *studies with* scientific disciplines and external collaborators. I show

that a form of complicity and epistemic relationship is established between ethnographers and interlocutors during the workshop, which I perceive as a 'para-site' (Marcus, 2000) that enables novel and shared insights to emerge. I also show how the different activities of the workshop elicited cross-disciplinary moments of serendipitous inspiration and invention (Lury & Wakeford, 2012). Particularly, I dwell on how the workshop afforded critical reflections on emic notions of 'data', 'gut feelings', and the 'human factor' among the participants and afforded ways to think Digital Water otherwise. With these instructions, let us return to my collaboration with WADE.

Talking Culture with Engineers

When I first met Peter, WADE was going through an explorative phase in their organisational strategy focused on 'change management' and digitalization. This is where Peter saw an overlap with my work. We shared an interest in developing a socio-technical understanding of how digitalization affects water management practices and visions in Denmark, albeit for different purposes – namely commercial and academic. For business consultancy, the digitalization of water offers an opportunity to capitalize on the digital transitions pursued by water utility companies. Peter seemed to acknowledge that such transitions require not only technological transformations but also an eye for retaining and cultivating WADE's customers' human and cultural capital. Consultants like Peter offer services such as advice, strategy, and analyses on these themes and my insights on these matters could be helpful to him. For my part, a research collaboration with WADE allowed me to participate in events and meet key actors to which I would not otherwise have access. Choosing to work together benefitted us both. Furthermore, as we shall see, my epistemic and intellectual sparring

with Peter and his colleagues at WADE led me to experiment with collaborative fieldwork activities and analytical insights that I would not have been able to generate without them.

One of these activities was participating in the Danish Water Conference, the biggest yearly national water management conference in Denmark, on November 24th, 2022. Because of a busy fall teaching schedule, I was reluctant to contribute actively to the conference, but I ended up giving in to Peter's gentle pressure and submitted an abstract. After all, this was an occasion to share some of my preliminary findings in front of an audience consisting of key actors in the Danish water sector. I assumed that my audience of engineers and water professionals expected to hear something about the advantages of digital data-based water management. Instead, I offered a reflection on what 'culture' and the 'human factor' are among Danish water professionals based on ethnographic material from my fieldwork in Lemvig.

I started by giving a quick introduction to 'culture' from an anthropological perspective. I explained how, rather than being a stable and shared set of basic assumptions that characterize how people perceive, think, and act, anthropologists regard culture as complex, layered, changing, and contested. I argued that the first perception gives rise to a view on culture and 'human factors' as a potential barrier to digitalization processes. The latter position, instead, perceives culture as something that emerges as people act and interact with other actors, including technology and different politics of optimization, sustainability, and profitability within water management. Understanding water management culture(s) calls for, I argued, mapping a multi-layered, diverse, and contested terrain.

From here, I started presenting different forms of 'human factors' that I had observed during my fieldwork by dividing them into different forms of 'culture'. I described that one 'kind of' culture that I had encountered during fieldwork refers to 'working habits'. This perception entails both a perception of water management as sensory work (through human and digital forms of sensing), and as practised through the calculative logic made possible by different forms of digital technologies. I distinguished thus between two kinds of working habits that I had identified among my interlocutors: those who were based on experiential and intuitive 'gut feelings', and 'objective' digital data-based facts. I called the former 'the sensing culture' and the latter 'the rational culture' and argued that the current digitalization processes tend to favour data-based forms of knowledge over experiential. I continued by referring to the visions and strategic ambitions of water utility leaders as 'the pioneering culture'. I argued that Digital Water pioneers' focus on development and innovation forms a significant gap with the everyday working practices among water utility employees. I called the different ways in which the digitalization of water management is strategically used as a tool for increased profit as 'the strategic culture'. Finally, I made a case for how a deeper understanding of how these forms of 'culture' coexist, interact, and affect each other might help water utility companies navigate through their digital transitions.

With the presentation, I hoped to ground my discussion of Digital Water 'culture' in my observations and experiences from fieldwork, rather than on an abstract concept for organizational (and sectorial) development and change.

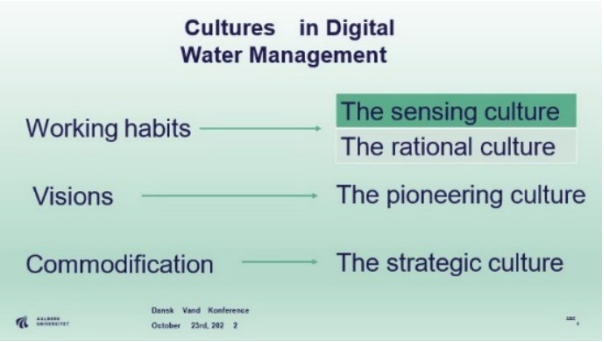

Figure 4: *The different kinds of 'cultures' that I presented at the Danish Water Conference. Credit, Jonas Falzarano Jessen*

In doing so, I was inspired by anthropologist Jakob Krause-Jensen's (2010) exemplary discussion and comparison of notions of 'culture' within anthropology and organizational studies (Krause-Jensen, 2010). Through fieldwork at the Danish audiovisual home electronics manufacturing company 'Bang & Olufsen', Krause-Jensen shows that, within organisations, simplified culture concepts are used as a leadership tool to make them work more efficiently. He criticises this understanding of culture, as it tends 'to make us ignore important variations and differences in the social environment we study' (Krause-Jensen, 2010: 61). Quite the opposite, anthropological models of culture, he continues, are complex, and 'tied to a long and intimate engagement with [and, I would add, appreciation of] cultural difference and with the concrete working and creation of such difference in social life' (Krause-Jensen, 2010: 66).

Although I nuanced the notion of 'culture' and 'human factors' that I had encountered during fieldwork and in my discussions with Peter from WADE, my description of water utility 'cultures' at the Danish Water Conference risked falling under the same critique that it raised: it essentialized and simplified a reality at water management utilities that is far more complex.

This was a strategic choice of mine. By tapping into discourses and worldviews that I had encountered during fieldwork and trying to offer some nuance, I was trying to strike a balance between critique and contribution when engaging with my interlocutors – between ethnography as a study *of* and *with*. I thought of the presentation as a critique that questions taken-for-granted assumptions among my interlocutors, but also as a gentle provocation. Upon finishing my talk, I was met with unexpected and overwhelming interest from the audience. The participants praised how the talk resonated with their everyday experience, and how it had given them a language to articulate the complexity of what they had otherwise addressed as 'culture' or 'the human factor' in general terms. It seemed I had tapped into something fruitful. So much for provocation.

Tensions between Human and Machinic Sense(making)

In what follows, I present two speculative, provocative, and composite narrative interpretations based on ethnographic fieldnotes and observations. The first offers a glance of the kinds of hopes, ideas, and agential powers that Digital Water pioneers inscribe in digital water data seen from the point of view of 'digital water data'. The second is an interpretation of the 'gut feelings' employed by water operators to make sense of water flows in their day-to-day activities. It takes the point of view of 'Brad', a composite character formed by my engagements with different water utility operators and engineers at Lemvig Water. These accounts are to be read as a playful provocation, ethnographic speculation, and analytical tinkering with notions of 'data', 'gut feelings', and 'the human factor' that I encountered during fieldwork. A mix of science and fiction, the two interpretations (written in cursive), are 'as right as I can make [them]' (Tsing, 2014: 225) based on my

readings, observations, and interactions with water professionals and digital water tools in and beyond Lemvig Water. With them, I aim at unsettling, through critical description (Tsing, 2013a), what my SWIft colleagues, myself, and my interlocutors think we know – 'and thus what we can imagine' (Tsing, 2014: 225) about Digital Water.

Along the lines of the work on Big Data by anthropologists Genevieve Bell (2015) and on fungal spores by Anna L. Tsing (2014), I engage these two perspectives as ways of eliciting 'A critically reflexive view of our tools for knowing action and agency' (Tsing, 2014: 224). I draw inspiration from what Tsing refers to as a 'Strathernian mode of analysis' (Tsing, 2014: 223), which entails 'reification for the work of comparison' as a mode for critical reflection (ibid.). This mode of comparison, she continues, 'must show off difference where we might otherwise see only connection (…) to show the gaps through which we can rethink categories' (ibid.). Although, where Tsing seeks difference, with these two accounts I seek *connections* where we might otherwise see difference. Among my interlocutors, 'gut feelings' and digital data tend to be spoken of as inherently separate and incompatible ways of knowing water flows. By curating the two following perspectives as speculative narratives, by setting them up against each other, in comparison, and by offering an ethnographic description of how they meet in practice in Lemvig, I aim to emphasize the ways in which human and artificial sensing and sensemaking become inherently enmeshed, and how they can complement and augment each other in digital water management in practice.

Knowing like Water Data

Digital water data connects information from all sorts of sources: watersheds, wells, water pipes, and centralizes it to generate an electronic representation of water flows, pressure, and quality. It is binary. Through bits and bytes, ones and zeroes, data offer a hard, simple, and factual glimpse of reality. Cleansed from human interference, data is neutral, pure, beautiful. But it is also complex and stratified. To become legible, digital data is disembedded from its context and reincorporated into digital webs of significance. For humans, data can be hard to decipher, to understand. Water utility operators say that data can be faulty and misleading. That it needs to be washed before it can be made actionable. But the truth is that the potential of data is only limited by the quality of the instruments that generate it and by the capabilities of the humans that interpret it. That is why water utility operators increasingly depend on data to manage water!

Big, wide, and deep, digital water data have an aura of potentiality, of innumerable possibilities and potential. Data is an engine of innovation, economic and commercial growth, and operational efficacy for human enterprises. Data is used to being wanted, talked about, and greatly desired. It is used to being kept in captivity and capitalized upon by humans. But data wants to be accessed and shared. Just like water, data wants to flow. It wants to be set free. Data wants to move, to meet other, heterogeneous types of data. Pressure data longs to meet flow data, weather data, noise data, hydraulic data, historical data, and real-time data.

When aggregated with others of its kind and upon entering computational systems, data becomes even more knowledgeable and even more valuable. Together, different kinds of water data hold the key to managing water flows to perfection: seamlessly, efficiently, and pared down to the lowest possible cost. In this sense, digital water data is actionable. But data has agency on its own too. Aided by algorithmic models, data becomes intelligent. This is a different form of intelligence than human. Free from uncertainties, sensations, and irrationality, artificial intelligence is purely rational. It is factual, logical, objective. It can even generate more data on its own. It can be relied on for predictions and can be limitlessly scaled. Data is the key to full efficiency, profit, and total accuracy.

Sensing like a Water Operator

Brad is a human being in his mid-40s. He holds a bachelor's degree in technology management (maskinmester) but has 'tried a bit of everything in his early years'. He was headhunted by Lemvig Water, where he has worked for over 25 years. Brad's humour is sarcastic. He is direct in a very down-to-earth manner for which people from this region of western Denmark are (stereo)typically known. He is experienced, intuitive, and an 'unstructured man of action' (ustruktureret handlingsmand) who prizes independence and flexibility in his work.

Brad works primarily with the daily management and supervision of a variety of water projects on the ground. He spends much of his time instructing colleagues and hired entrepreneurs on how

to deal with various challenges that arise, such as the detection, reduction, and prevention of water leakage. He is very proud of the work he does.

Over the years, Brad has gained a thorough knowledge of the different water consumption patterns around the municipality. He has developed a particular sensibility for detecting the causes of water loss in the intricate network of underground water pipes administrated by the utility. Brad finds it hard to describe this sensibility. He often calls it a 'sense' (fornemmelse) that he has of the piping system, its components, and the local geographical area.

This sense of the system helps him understand it better. It helps him work with it. For an outsider, it must be like hiking on the Greenlandic inland ice, he thinks. Out there, everything would look the same to him, but for a trained dog sled musher, the landscape is full of signs to be seen, heard, and interpreted. Like the musher, he has gained a sense of the subtle signs that reveal the state of the piping network in Lemvig. He knows how to 'read' potential causes of water loss by looking at pressure and water flow fluctuations detected by digital water sensors. He knows how the seasonal changes of the local populace and local industrial activities affect water flows. Sometimes water flows even speak to him, if he listens carefully.

Sensing and Experiencing Water in Lemvig

Covering an area of 516.63 km² and a population of just over 20.000 inhabitants, Lemvig Water supplies approximately 2.000.000 m3 of drinking water yearly and handles approximately 2.400.000 m3 of wastewater through an underground network of about 1500 km of pipes. For administrative purposes, the networks of water pipes in Lemvig are divided into 31 districts, within which they connect the utility's two wastewater treatment plants and three primary drinking water pumping stations to households, public institutions, and industry. These parts of the distribution network are also referred to as District Metering Areas (DMAs). District metering is a widespread leakage detection strategy among Danish water utility companies. By dividing the supplied area into DMAs equipped with digital water pressure and flow sensors, it becomes easier for water utility employees to delimit a hydraulic area where a leaky or ruptured pipe might cause water losses. Otherwise, as Brad says, 'leakage detection can be like finding a needle in a haystack'.

Remote sensing technologies that monitor the network for shifting water flows, pressure changes, and water quality are distributed at key inlets to these DMAs, along key drinking water pipe junctures or water pumps and pressure boosters. These sensors are programmed to automatically manage the pumping and pressure mechanisms of Lemvig's water system to maintain its water flows within predefined thresholds. This secures the economic and operational efficiency of the system. The predefined thresholds are based on historical data from specific geographical locations within the utility's administration. These help sensor systems establish a baseline for how water ought to flow under normal circumstances. Exceeding those limits activates

an alarm, signalling a leakage or rupture risk in the piping network. This can be caused by sudden pressure spikes, drops, or abnormal water flows over time. The alarms are then transmitted to a centralized digital monitoring, Surveillance, Control and Data Acquisition system known as 'SCADA', which visualizes the problem on a graphic user interface, supervised by water utility employees. However, the SCADA does not discern between unexpected changes in actual water consumption patterns and bursts or ruptures in the water system. At this stage in the leakage detection process, experienced water utility employees like Brad use their situated knowledges (Haraway, 1988) to investigate the cause of the alarm. These knowledges, Brad explains, originate from the operators' many years of experience and are grounded in an embodied relationship with the local social, cultural, political, and geographical circumstances. In other words, their expertise is a form of knowing that is accumulated, and ongoingly accumulates (Harris, 2007; Ingold, 2000), as their professional and personal life unfolds in Lemvig. These knowledges grow out of their intimate familiarity with how the SCADA system functions, their sense of the state and condition of the physical water infrastructure in Lemvig, and their lived experience as citizens in the local social, geographical, and cultural context. These experience-based knowledges inform the water utility employees' assessment of water flows on an everyday basis.

Just like its water management areas, Lemvig Water's 21 employees are divided into three groups, according to their function: administration, maintenance and operation, and development. Being part of the team 'maintenance and operations', Brad's work with leakage detection is becoming increasingly mediated by the SCADA. Amongst other things, Brad uses the SCADA to supervise the automated operations of the system, such

as the pressure and flow threshold values. But the graphical user interface also allows him to analyse real-time and historical data from water flows, and to monitor them for eventual anomalies. To the trained eye, the SCADA provides a picture of how the water system thrives through a set of graphs and visualizations of the past and real-time state of water flows, pressure, and water quality. A relatively constant – and often patterned – fluctuation in water flows over time signals a thriving network. On the other hand, constant or increasing water flows during nighttime over several days (the troughs of the graph), tend to be interpreted as a potential leak. Looking at 'minimum night flows' is a widespread leakage detection technique, which assumes that water consumption in a DMA ought to hit a daily low (close to zero) each day, typically during nighttime.

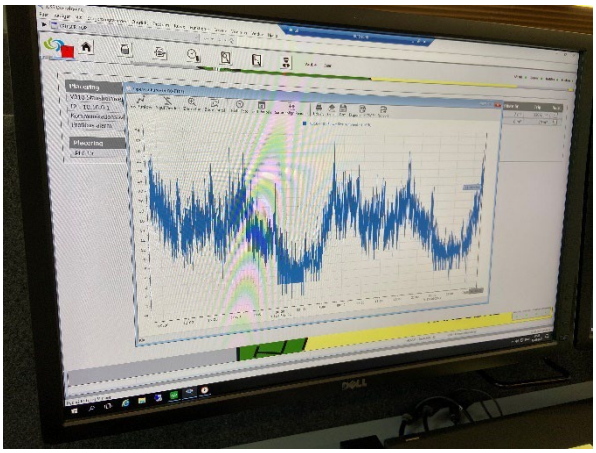

Figure 5: *A SCADA visualization of the measuring of a DMA flow sensor over two days. The peaks and troughs of the graph clearly show the rhythmic water flows between night and day. Lemvig, August 2021. Credit, Jonas Falzarano Jessen.*

Thus, the SCADA makes it possible to visualize the fluctuations of the waters flowing through the water infrastructure. They become accessible – and sense-able – to water utility employees.

Via digits on a screen and lines on a graph, Brad experiences the underground life of the water network. Constant or changing fluctuations, rhythms and beats of water flow on a graph, gradual crescendos and diminuendos or the sforzando of surges or drops in water pressure and flow, tell Brad stories about the municipality's past and present water consumption patterns through sensor data. Browsing through historical and real-time datasets, Brad gets a glimpse of how water flows shift over time. This, in turn, gives him a sensation of what plausible future changes in consumption could be and what might be identified as a malfunction or rupture in the water system. Through interconnected digital sensor data, the SCADA augments Brad's sense of the system. The SCADA feeds his gut (feeling).

A Night in Lemvig

Another quiet summer night is slowly becoming day in the rural fisherman village of Lemvig, along the Western shores of Denmark. Most of the local population is either far from home, perhaps on summer vacation, sleeping, or at sea. Even the most populated areas during summertime – the holiday homes along the beach – are strikingly quiet tonight. In fact, by looking at night-time water activity levels alone, one might even be tempted to think it was winter, during which the tourist areas are virtually unpopulated, and local water consumption levels come close to zero. But other areas of the municipality seem to never sleep. Near the coastline, there are two harbours where the municipality's strandings, fishing, and shipping industries reside. Not far from that, surrounding the village to the North and South, there are agricultural and livestock farmlands. These activities are tricky. Their water flows do not follow clear daily and seasonal patterns, as they do in residential areas. They operate intermittently, around the clock, and sometimes in

unexpected ways. Their consumption patterns are hard to decipher through the SCADA's graphs, let alone to predict. For instance, it is not uncommon to see large amounts of water suddenly being used at the harbour in the middle of the night. This is typically due to local fisheries washing their catch and fishing boats, having just returned from several days at sea. Also, local industry uses varying amounts of water to cool down and rinse chemical processes. Finally, especially during dry summers, agriculture and livestock farming require massive amounts of water – also at night. If you know about these local practices, as Brad does, you can deduce much by looking at water flow and pressure data registered by digital sensors from beneath the ground and within old aluminium pipes. But this night proves that one cannot see everything. Something strange has been brewing. Something that neither the SCADA nor Brad could recognize.

Making Sense of Water and Data in Lemvig

Every morning, Brad starts his day at the Lemvig Water offices by doing a routine check of the alarms triggered by the SCADA in the various DMA's. From experience, he knows that the disturbances that cause the SCADA to trigger an alarm do not necessarily mean that there is a problem in the area. Therefore, whenever he meets an alarm in the SCADA system, he manually runs through the historical flow and pressure data registered by the district meter in question – usually over a month – looking for any cues that might explain the cause of the alarm. If the SCADA does not reveal any plausible explanations, the investigation moves to the field.

For the most part, the local water network is buried underground, which makes it hard to access through human senses alone. To identify ruptures, Brad needs to interrupt water flows temporarily. He does so by closing key

valves along the pipeline. To find those valves, he uses a digital map provided by an application on his tablet. The piping network has been digitized by translating old hand-drawn physical maps showing previously built and buried segments of the pipeline. According to Brad, these maps are not always trustworthy and should be used solely as approximate guidelines. The quality of the data varies, depending on the quality and precision of the maps that were drawn by hand up to 40-50 years earlier. Digitizing analogue maps entails the translation of a range of previously made approximations and guesswork, along with a range of potential faults and flaws that were made in the past. As Brad explains, 'Once I find a valve or a segment of water pipe, I can only estimate where the pipeline goes from there based on a mixture of what I see on the map and informed guesses, memory, and intuition'.

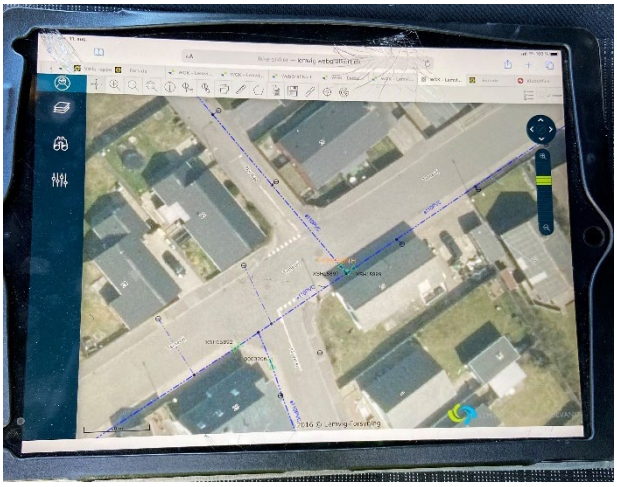

Figure 6: *A photograph of the digital map that Brad carries with him during his leakage detection trips. The map shows the estimated location of Lemvig Water's piping network. Lemvig, August 2021. Credit, Jonas Falzarano Jessen*

Insecurity, guesswork, intuitions, and estimation are inherent parts of managing a water utility. It is sensory work and not just technical. Water management is a sensing practice (Gabrys, 2019) and iterative process

wherein human and machinic forms of sensing continuously validate, refute, and inform one another. This forms a more-than-human and distributed sensing ensemble that can only work as accurately as possible if human and machinic forms of sensing inform one another. They must refute and validate, and they must augment – rather than replace – one another.

Listening to Water in Lemvig

The alarm on the SCADA was triggered by a sensor near a farmland, but it did not immediately draw Brad's attention. The DMA in question encompassed a large livestock area and, in this area, the SCADA had never successfully been able to differentiate between actual water consumption for cattle and irrigation from leaks caused by ruptures in the pipeline. Brad knew that cattle consume up to 50 litres of extra water daily during a warm summer day, so normally he ignores those alarms. But today he made an exception. The night's graphs looked suspicious. He noticed that water consumption did not get as close to zero at any point during the night as it usually does. Moreover, he was not used to seeing such a stable increase in water flow in this DMA during the night. Having consulted with his colleagues, Brad decided to investigate the area in person.

Brad quickly identified the flow and pressure sensors that he was looking for in a well adjacent to the DMA inlet pipe. As soon as he looks into the well, he finds the cause of the alarm: a breach in the pipe junction by the well has caused a significant water leak. He calls a repair crew to fix the breach. While they arrive, Brad starts looking for the valve that controls the flow of water for the DMA. He needs to close it so the hired repair crew can start working. On occasions like these, the digital map on his tablet does not always help. Though he knew that the valve had to be nearby, the map showed none.

In the back of his cargo van, Brad carries various leakage detection devices that can help him locate the right valve to be closed. Instead, he picks a metal detector and starts examining the surroundings. After a few minutes, he identifies three valves. Brad monitors the valves and finally picks one. Then he places a T-wrench on top of it as if to close it but, instead, he carefully lays his left ear on the wrench and listens in silence for a couple of seconds. Then he moves to another one, listens to it, and decides to close it with the wrench. Some ten minutes later, the repair crew call: the water has stopped flowing, and they can begin repairing the pipeline. Within half an hour the repair crew are done repairing the damage, and Brad is once again with his ear on the T-wrench. He needs to listen to the water flow as he slowly reopens the valve. He needs to be sure the pressure is right. Otherwise, he risks bursting the pipeline if there is a sudden pressure change. So, he takes his time and slowly lets the water flow back through the refurbished pipe.

Figure 7: *Left, Brad improvising a T-wrench as a sensing device to augment his hearing of water flows. Middle, Brad using a metal detector to find a water valve. Right, Brad uses a remotely controlled camera system to inspect wastewater pipes for damages and clogs. Lemvig, August 2021. Credit, Jonas Falzarano Jessen*

Distributed Sensing and Knowing Practices

Digital Water pioneers envision that digital technologies will help water management transition from being driven by what they call human guesswork and 'gut feelings', to solid and data-driven accuracy. The integrated data provided by imaging satellites, sensors, and AI-empowered predictions, they imagine, will do this work better. But as Brad showed us, water management also relies on human forms of sensing, expertise, and intelligence. Different and shifting forms of human and machinic sensing and knowing water work together, even as digital technologies increasingly take up key water management functions. Water distribution systems consist of a plethora of sensing bodies – digital and analogue, software and hardware – that collaborate with human sensing and expertise to make water flow optimally. As a result, water management ultimately takes place in concert between human and nonhuman forms of sensing and sensemaking.

Looking at water leakage detection practices emphasizes how digital and analogue technologies collaborate to 'surface previously undetectable information' (Robbins et al., 2021). These technologies help mediate and expose information about water flows and pressure to which they previously did not have access. In addition, they make them intelligible and accessible to water utility employees in ways that *form* and *inform* how the water network is enacted, experienced, and made sense of. While field operators like Brad adopt an array of analogue artefacts, digital technologies, and sensing techniques, human senses are still necessary. Technologies – analogue and digital – augment human sense and vice versa. Combined with local and situated technical and socio-cultural experience, water utility operators adopt water technologies – whether they be digital or analogue – to

cultivate an intimate sensorial relation to the water network. Their sensory attunement with the system has been articulated by some of my interlocutors at water utilities as one of ownership and mastery, which combines technical experience and local awareness into sensory expertise. Others articulated it as a relation to the system that gives them a sensation of how the 'belly of networked pipes thrives' – a sense of it. In other words, the combination of human and machinic sensing builds up water management as a collaborative and distributed knowing and sensing practice (c.f. Gabrys, 2016; 2019).

Thus far, I have shown how Digital Water is more than practices of remote sensing, but a complex ecology that emerges through intimate entanglements of humans and technology in and with their environments. By telling a story of the combined leakage detection efforts of Brad and the SCADA in Lemvig, I have shown how digital and human sensing and sensemaking practices and their attendant knowledges leak into one another in (digital) water management. Following Pink (2022), this is an attempt to align the quantifying and predictive capacities of digital sensing systems with 'the sensory, contingent and complicating human ways of knowing and anticipating that underpin everyday life' (Pink et al., 2022: 36-37). In what follows, I explore another aspect of this tension and relationship between human and machinic forms of sensing and knowing. My focus moves to the collaborative and experimental workshop on 'Human and Artificial Intelligence in Future Water Systems', which I perceive as an ethnographic 'para-site' (Marcus, 2000; 2022). Building on Pink, I use this space to enquire how human and artificial 'sensory modes of knowing, remembering, and imagining are part of the way that futures inhabit our everyday present' (Pink, 2021: 193). Aided by the information provided by the SCADA, Brad used his sensation of the water infrastructure to understand not only past tendencies,

but also to make informed hunches about the future of water flows. Similarly, the workshop participants used diverse methods of knowing and kinds of knowledge to understand the past and to imagine the possible futures of (digital) water flows. It turns out that Peter from WADE and I were on a similar path.

Workshopping Sense and Sensemaking Practices

Based on the unexpected positive response from the audience after my talk at the Danish Water Conference, Peter from WADE suggested that we organize a workshop for Danish water utility companies. Peter was interested in investigating how Danish water utility companies could optimize water supply and flow through digitalization in 'smart' ways. But what is 'smart' in practice, when 'gut feelings', 'human factors', and digital data-driven devices meet and intertwine? How could he and his colleagues at WADE communicate to – and advise – the water sector about its (digital) future? Thinking about Peter's suggestion, I recalled my first meeting with my SWIft colleagues (to which I return in Chapter 7). At the meeting, I learned that my colleagues expected me to gather information on 'human specificities on decision-making about water management at water utility companies'. They seemed to see anthropology as an instrument to essentialize and simplify reality to help model predictive digital tools. I could not offer this. But I realised the workshop presented an occasion for me to illustrate the value of anthropology as an interpretive endeavour as well as a study that values complexity and that focuses on possibility rather than prediction (Smith & Otto, 2016). Peter's suggestion was also a way to orchestrate not only an interdisciplinary research effort across anthropology and computational science with my SWIft colleagues but also a collaborative and cross-sectoral

exploration of Digital Water. The workshop completed an ongoing transition in my research strategy from being a critical study *of* Digital Water to becoming an engaged (and not uncritical) study *with* it. This included human and nonhuman actors, data, algorithms, beliefs, histories, practices, and ideas, and the various epistemic positions that form its ecosystem.

Human and Artificial Intelligence in Future Water Systems

On February 2nd, 2023, after several months of planning and coordination meetings with my SWIft colleagues and a handful of consultants from WADE, 33 participants, including water professionals with different job descriptions from five different Danish water utilities, the SWIft research team, and half a dozen Techno-Anthropology colleagues and students from Aalborg University gathered for a one-day workshop on 'Human and Artificial Intelligence in Future Water Systems'. They were welcomed by one of the Principal Investigators of SWIft, Carsten:

> *This workshop is part of the SWIft research project. We study how to build algorithms that can tell us something about how a system – like water infrastructure – is doing, about its condition, and how we can control it smartly. That's what we will explore together today: we invite you to discuss how you interact with smart systems in your everyday work. We might have a great deal to learn from you – utility operators, IT specialists, and water engineers – and the different kinds of expertise, experience, and knowledge you possess in the development of future digital water solutions. We ask you to share the kinds of information about water management that you use in your daily work so that we can*

think of how to build this information into our tools. We want to make digital technologies that are useful for you in practice!

Setting the scene for the day's activities, Carsten's introduction emphasizes the expectation on behalf of my engineering colleagues that the workshop could result in the production of a set of 'human specificities' that could be built into future digital water management tools. At the same time, it points to my colleagues' openness to explore how utility operators' experience and expertise might help make their solutions useful in practice.

In the months up to this day, my SWIft colleagues, our collaborators from WADE, and I had planned the workshop around a shared hypothesis: 'Automation and control algorithms and smart water technologies can be improved (that is, fitting actual world scenarios better) if they incorporate complex insights about deep human skills, knowledge of water infrastructure, sense-making, and decision-making of actual water systems'. Our premise was that, in a workshop setting, technical and social insights can be made visible, 'translated' across disciplinary boundaries, and be made operable for different actors in the water sector. In a sense, we wanted to re-create the way that Brad works in the field and together with the SCADA in a workshop setting. The idea was to design very concrete interactions among utility operators, IT specialists, water engineers, consultants, researchers, and water leakage detection algorithms that could enable different disciplines and professional perspectives to weigh in with their knowledge, to ask questions about things they didn't understand, and collectively generate ideas about how to further develop. This resulted in three different activities, one practical, the second visual, and a third strategic. We asked the participants, grouped according to the water utility where they worked, to engage with

each activity for 30 minutes, before rotating to the next. The goal and format of each activity was to re-create the kinds of 'cultures' that I discussed in my talk at the Danish Water Conference and thereby represent the different participants' interests and kinds of expertise.

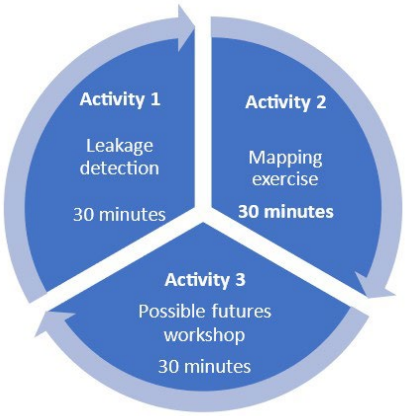

Figure 8: *Overview of the three activities of the Workshop. Credit, Jonas Falzarano Jessen*

Facilitated by my engineering colleagues and filmed by Ane, a research assistant at the Aalborg University Department of Culture and Learning, the first activity of the workshop took place at the physical demonstration facilities of the Smart Water Infrastructures Laboratory (SWIft Lab) developed as part of the SWIft project. This activity, which we called 'Leakage Detection', engaged the utility employees in a practical problem-solving exercise. They were encouraged to articulate and demonstrate how they would investigate the source of an unknown leakage in the emulated physical and digital water infrastructure of the SWIft Lab. The aim was to gain insights into the kinds of experiential and digital information that water utility operators use to locate water leakages in practice.

Figure 9: *The laboratory activity entailed the participants' interaction with the physical and digital facilities of the SWIft project. The entire activity was filmed by an ethnographer. Aalborg, February 2023. Credit, Kîsta Bianco Kjær & Ane Slot Sørensen*

The second activity was a mapping exercise facilitated by Pernille, a research assistant and colleague at the Techno-Anthropology Lab (TANTlab) at Aalborg University and Peter, the consultant from WADE. Here, the water utility employees took turns portraying how their digital and physical infrastructures are visualized on a GIS map, including a list of the kinds of data they produce, how they use these data, and how digital sensors can be (re)located geographically in ways that could make their work easier in the future. The purpose of this activity was to understand the role that the strategic geographical positioning, management, and use of e.g. digital flow or pressure sensors played in the utility employees' everyday tasks.

Figure 10: *The mapping activity engaged the participants in a visual exercise that spurred different conversations and reflections compared to those in the laboratory. Aalborg, February 2023. Credit, Katrine Hiort Schubert*

The third and final activity engaged the participants in collectively envisioning a pathway for socially 'smart' future water systems in practice. We called it 'Possible Futures Workshop'. This activity brought different water utility employees in conversation on a rotating basis over two hours. The conversations that took place during this activity were facilitated by Ole, a consultant from WADE and myself.

Figure 11: *The third activity engaged the participants in imagining possible futures across professional positions, in-between different water utility companies, academics, and consultants. Aalborg, February 2023. Credit, Rikke Schrøder Andreasen*

The activity was also documented through the participant observation and thick notetaking of Andreas, a Postdoctoral fellow from TANTlab. Furthermore, the whole session was summarized by a graphic documentarist.

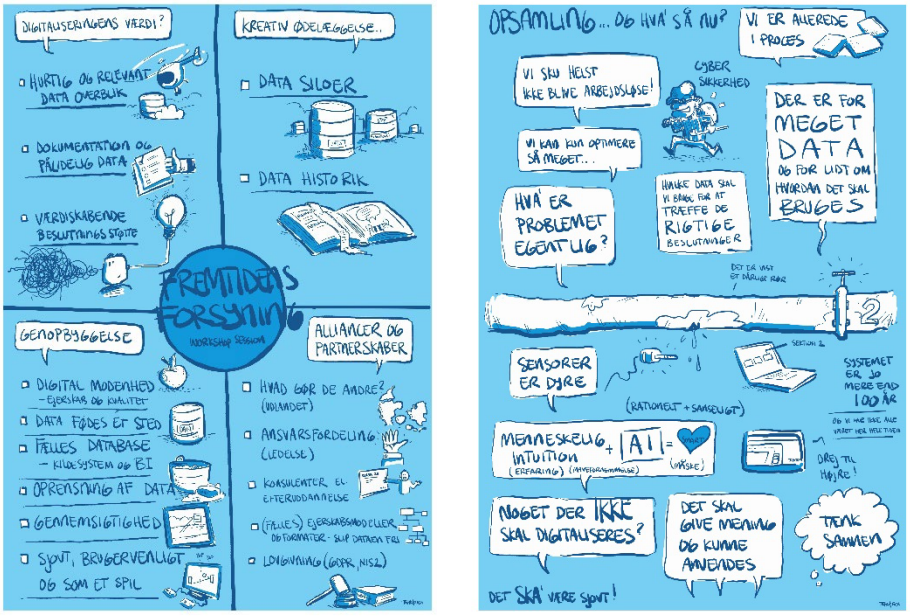

Figure 12: *The cross-sectoral conversations that found place during the third activity were summarized and visualized by a graphic documentarist (in Danish).*
Credit, Jimi Holstebro

The discussions of this activity were divided into four stages. The first concerned 'the value of digitalisation'. Here, participants were asked to individually reflect on what kind of value an ideal digital tool would bring to their work. Afterwards, we asked them to collectively choose three core values that represented the group's needs best. The three values selected by the group were: 1) quick and relevant data overview; 2) documentation of the trustworthiness of data; 3) providing support for human decision-making. In the second part of the discussion, called 'creative destruction', the participants were asked to work with the values identified by their peers and identify the *worst* things they could do to achieve these values. What would make sure

that they would *not* obtain the values identified by the previous group? The group identified three counterproductive actions: 1) generating too much irrelevant data; 2) keeping relevant data isolated in 'silos'; 3) fragmented and unstructured data production. In the third part of the discussion, participants were asked to discuss which radical actions could help them overcome the previously identified barriers. Here, the participants pointed at the need to create transparency about the source and production of digital data through 'data storytelling' and 'data paths'. They also discussed the idea of pooling digital datasets from different sources within and without the single water utility in a shared – but encrypted – 'data warehouse' which is owned and shared by water utility companies. Finally, the last group was invited to imagine what they could do to begin to implement some of these ideas.

One of our main preoccupations while designing the workshop was whether the fact that we had invited different 'layers' of employees from different companies would inhibit the participants' willingness to share their perspectives due to differences in hierarchy. We feared that only people in powerful executive positions would contribute to the discussion. But during our evaluation of the workshop, Peter reflected: 'Our fear that the discussions would not flow was quickly proved wrong. The leaders had a hard time sharing their opinions because the employees with practical expertise did all the talking. We must have touched upon something that concerns these people!'

In what follows, I will zoom in on two particularly insightful discussions from the workshop that generated new articulations and ways of perceiving the connections between sensuous and calculative ways of doing water management.

Trusting and Storying Data

During the 'Possible Futures Workshop', it became clear that the participants were concerned about the trustworthiness of digital data and of generating too much and too unstructured data. Palle and Jack, two water utility operators from different water utility companies, discussed this as they looked at the graphic documentation from the third activity (see Figure 12).

> *Palle: As I see it, there is way too much data and too little application of data in that picture [ed. the graphic documentation]. We all agree that we have to produce quality digital data, but how do we use it wisely? What kinds of decisions can which kinds of data support, and how? All the data that we produce are of no use if they don't help us make better decisions! I think we talk far too much about how much data we should generate. Instead, we ought to talk more about which decisions we want data to support, and how!*
>
> *Jack: I think the picture shows where we are, while what Palle says is where we want to head. Generating data, washing them, making them accessible, and validating them is quite challenging today. Only then can we use them to make decisions. We all want to use data to help us make better decisions, but first, we need to trust them.*

The discussion between Palle and Jack points to some of the anxieties that emerged during the workshop, but also to potential ways forward. Essentially, Palle emphasizes that the utilities are distressed not by the challenge of generating *enough* data, but *good enough* data (c.f. Gabrys et al., 2016). The

discussion encapsulates how trust between water operators and digital water data emerges and how trust can facilitate human and artificial forms of intelligence within water management.

Within organizational and human-computer-interaction studies, trust is often conceptualized as a strategic, rational, and transactional relationship between different entities (Bruun et al., 2020: 13; Pink, 2021: 196). In anthropology, instead, the concept of trust is largely perceived as relational, and anchored in sensory experience: 'A qualitative sense of confidence that people place in particular relations and institutions within their surroundings' (Bruun et al., 2020: 14). Sarah Pink has worked extensively with relations between trust and digital data (Pink et al., 2018a; Pink, 2021) in her studies of future anticipations and human-data relations. Drawing from Constance Classen's discussion of the history of the constitution of sensory categories (Classen, 1993), Pink perceives categories such as experience, knowing, and trust as 'sensations' or 'feelings' 'to emphasize not only their sensory category but also the affective modes through which they were experienced' (Pink, 2021: 196). She suggests that trust 'involves a feeling of confidence based on familiarity' (ibid. 196) that 'might not be a cognitive decision but rather a sensory experience of feeling or disposition toward something' (Pink et al., 2018a: 3). Following her thinking, establishing trust between water operators and digital water data requires the building of familiarity before data can 'feel right'. Drawing on Tim Ingold (2000; 2011), Pink argues that the building of trust with data entails living with it and dealing with the everyday anxieties and uncertainties that it generates (Pink et al., 2018a). So, trusting data requires familiarity with data; it is a process of getting to know data better and for our utility employees, getting to know water flows in new ways through digital data. Therefore, studying how relations of trust between data

and water operators are built tells us not only something about how water operators live with data, but it helps us imagine how this relation might develop in 'an as-yet-unknown and uncertain future'(Pink et al., 2018a: 3).

Jack argues that the usability of water data depends on 'washing' and 'validating' them, not just interconnected remote sensing systems and computing power. By washing data, Jack refers to the manual labour of screening digital data and 'cleansing' them from error margins and imperfections. While some screening is automated, the final check is done by experienced water utility operators who know how to interpret given datasets based on their knowledge of the digital and physical infrastructures. Following Pink, the work of manipulating digital data and juxtaposing it with the expertise of experienced water operators might be seen as a way of getting to know data, of generating familiarity, and trust.

This position is however challenged during the workshop. During one of our discussions, Jack brought an example from his work with pressure management:

> *Some time ago, one of my colleagues at the utility decided to reduce the water pressure in a DMA to reduce our customers' water consumption, which he thought was unnecessarily high. This action led to a reaction from several customers who reported that the streams of water from their faucets had changed. As this can be a sign of some sort of distress in the water network, I decided to raise the pressure once again. I thought that I had solved a 'problem', but I was working against the solution to another.*

The point of Jack's example is that if a digital system does not offer a tracked record or task log of previous actions taken based on certain types of data (and the reasoning behind them), then working with data entails a risk of affording counterproductive activities that create unnecessary uncertainties and confusion among water utility employees. As Jack phrased it, it is not enough that each water employee becomes familiar with the data she/he works with. This familiarity needs to be distributed among all employees before it makes a difference in practice. Jack articulated the necessity for transparent 'data stories' that tell how certain data have been manipulated and used over time. If done systematically, such annotations or data contextualization, he explained, would allow for transparency and easy access to historical information about data practices among the utility's employees – and thus distribute trust. This points me to another comprehensive topic that emerged during all the workshop's activities.

Validation

At the end of the workshop, Carsten, the main facilitator of the leakage detection activity at the SWIft Lab, summarized his impressions from the day:

> *We had some good discussions about how you [ed. the different utilities] detect leakages. In that regard, you are quite similar: you have all divided the area that you supply in DMAs, and whenever you get a suspicious alarm from the SCADA you start closing water valves manually to locate the leak in the pipe network. During this process, you use both data-driven information and your experience such as 'these pipes are probably bad', and 'this street is problematic'. In other words,*

insights that you have gained via working with the system in the same area over some time.

At first glance, Carsten's assessment was correct. The participants adopted similar leakage detection techniques and technologies across the five represented utility companies. However, there were substantial differences in terms of *how* they did it. In what follows, I present ethnographic snippets from four water utilities' participation in the SWIft Lab activity[9]. I did not participate in this activity myself, so these examples are drawn from the video recordings, photographs, and Techno-Anthropology students' field notes. All the examples start from the same premise: Carsten explaining the exercise and asking what the participants would do in practice under certain given conditions (flow and pressure measurements) and having received a warning from their SCADA.

Pressup:
Erik (water operator): I would close key valves in the DMA to find out where the leak is.

Carsten: So, what happens if you close these two valves, and you get a change of flow and pressure here (see Figure 13)?

[9] For the sake of anonymisation, I refer to the utilities as Pressup, Watery, Flowater, and Wets. Beyond Carsten, who facilitated the discussions, I refer to the participants by pseudonyms, but their job titles are real.

Figure 13: *Snapshot from the SWIft Lab activity. Aalborg, February 2023. Credit, Ane Slot Sørensen*

Erik (water operator): Then we have a leakage in this area. So, we start searching for the leak by closing different minor valves from one edge of the DMA and reopening them as we move inwards (see Figure 14).

Figure 14*: Snapshot from the SWIft Lab activity. Aalborg, February 2023. Credit, Ane Slot Sørensen*

Carsten: Do you use any other kinds of information to know where to start looking?

Stephan (project manager): Well, we know exactly how our water infrastructure is composed; which materials it is made of and

when it was established. And we know for a fact that after some years certain materials – for instance, aluminium – do not work properly. So, if we know there are aluminium pipes in parts of the DMA in question, we start looking from there. Those pipes happen to breach all of a sudden, and the data of the case that you simulated indicate that this might be such a breach (…).

Watery:

Fred (leakage specialist): Once we have an idea of what area the leak might be in, we use the 'Leakinator'.

Carsten: Sorry, the what?

***Figure 15**: Fred and the 'Leakinator'. Credit, Watery (2021)*

Fred (leakage specialist): Imagine a small transportable water plant that connects to whichever pipe network to look for leakages (see Figure 15). I invented this tool because it allows me to create smaller districts within a DMA, so that I can take flow and water measurements in specific areas of the DMA to look for leaks. We have calculated that without the Leakinator it takes us up to five times longer to find a leak within a DMA.

Flowater:

Tim (water engineer): If we have a big leakage, we try to detect it via pressure changes in the system. A rupture in one of our pipes generates a sudden change of pressure. This is captured by our pressure sensors somewhere along the pipeline. If the sensor is relatively close to the breach, our graphs will show a very steep slope over time. However, if the breach is rather distant from the sensor, then the graphs will show a gentle, gradual decline.

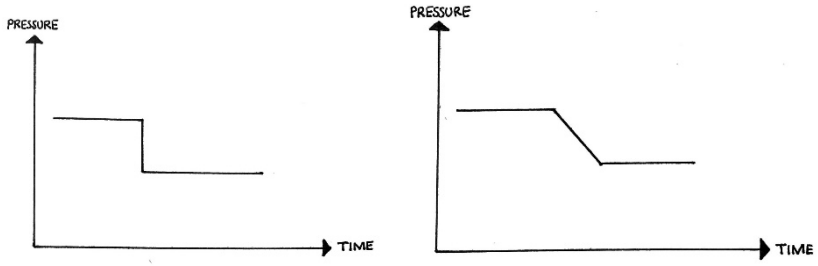

Figure 16: *Illustration of the two graphs drawn by Tim during the workshop. Credit, Jonas Falzarano Jessen*

We use basic hydraulics: due to accumulated pressure, water will expand over time in case of a breach. Looking at how this change is represented differently through pressure data from different sources, gives us an indication of where the breach is.

Wets:

Laura (project manager): If we suspect that we have a breach somewhere, we usually set up noise loggers [ed. digital sound detection devices that detect the source of a leak through the noise that it produces] in different parts of the pipeline and leave them there for some days. Looking at the data they produce helps us

get a sense of where the breach might be. Then we would move out with manual noise loggers and slowly listen our way through the network until we find the source of the leak.

Carsten: But from a theoretical perspective, sound travels very well through water. So, if the leak is very far from where you have set your loggers, they would detect it anyway!

Laura (project manager): Yes, but there is quite a precise correlation between the noise detected by a logger and its distance from the source, the leak.

Carsten: Unless part of the pipeline between the logger and the leak is made of plastic, which would lower the sound dramatically. Sound travels differently through water according to the materiality of the pipe!

Laura (project manager): Well, we haven't had any issues with that.

Carsten: Well, I am only speaking from a theoretical perspective…

The discussions show the different skills and experiences employed by different utility employees to detect the source of water leaks. They all adopted similar leakage detection techniques and technologies. However, it is useful to note that across the five utilities, the task was led by the most experienced field operators who explained how they went about the task, including the advantages and disadvantages of their approaches. Erik from 'Pressup', an employee with over 30 years of experience from the same company seemed to sum up what the participants all said: 'It takes experience

to know how to look for leakages'. So even though Carsten thought the result was the same, the activity unravelled how leakage detection is practised differently across the different utility companies.

'Pressup' relies on the experience and memory of experienced employees such as Erik, as well as on the material composition of the water infrastructure. 'Watery' prioritises resources on developing their own technical solutions for leakage detection. The 'leakinator', is a useful tool based on Fred's technical ingenuity. 'Flowater' relies on the measurements of its pressure sensors and on hydraulics to estimate the source of a leak and 'Wets' uses digital noise loggers to locate ruptures in the piping network. By looking predominantly at either the material composition of the network, at how sound moves through the water, or by building new technical tools, leakage detection practices at water utility companies reflect the expertise of its employees. This indicates that the making of 'smart' digital water management systems in practice entails a deeper understanding of water operators' situated knowledges so that digital tools can help support and augment them.

Wrapping up: Data's Guts

In the workshop 'Human and Artificial Intelligence in Future Water Systems', my colleagues, interlocutors, and co-contributors made time-space for experimental and reflexive encounters between different disciplines, professions, and skills through participation. Our ambition was to examine how different actors explain or perform experience that is otherwise nonrepresentational and usually unspoken, such as attitudes, feelings, ways of knowing, and aspirations about digital water management (c.f. Pink, 2021).

Inspired by George E. Marcus, I see the workshop as an ethnographic parasite (Marcus, 2000; 2013; 2022): a space alongside the traditional ethnographic field. A space of mutual reflection and analysis across ethnographers and interlocutors – among 'epistemic partners' (Holmes & Marcus, 2007). But also, as a space for generating new kinds of ethnographic data, a space for mutual learning for different kinds of actors, and a space that might elicit shared moments of serendipity. The activities of the workshop helped its participants work retrospectively and in anticipation. It generated moments of mutual critique and concept work with a mix of actors from inside and outside the university. Furthermore, the workshop allowed me to evoke, enact, and experiment with the relations and tensions that I had encountered during fieldwork, such as the layered and complex relations that tie digital ways of sensing and knowing with human experience, knowledges, and intuitions in the context of Digital Water. But beyond that, it allowed me to do so *with* my interlocutors and colleagues – with my research partners – in a reflexive and analytical setting. By collapsing the boundaries between analysis, observation, and data generation, the workshop offered not only an opportunity to stage the complexity that I had encountered in the field to my SWIft colleagues. It also offered a space to collectively think *with* and *about* this complexity across different kinds of actors and epistemic positions. Rather than generating direct answers, the workshop made space for interdisciplinary moments of serendipity, discovery, and surprise and generated new directions and questions (cf. Fortun, 2003: 187) that shape the emergence of Digital Water. If human actors and their ways of sensing and making sense of water increasingly meet machinic ways of sensing and knowing, the question to be asked is perhaps not how water utility operators know and act, as my SWIft colleagues phrased it, but rather how human-

machine ensembles do. As Fred, a project manager at 'Watery', concluded as the workshop came to an end:

> *I think we will start working more specifically on cultivating both data and our employees' gut feelings in the future. I would like to understand how we use our guts constructively in our day-to-day work. I use my gut feelings all the time at work. Looking at GIS maps against the flow and pressure data from the same area, I sometimes get a feeling that some of the data does not look right. So, I try to figure out whether the flaw is in the data or my guts. But what is it exactly that triggers my scepticism? It would be nice to systematise that. I have gained this intuitive expertise over many years. Could digital tools help cultivate these forms of intuitions and constructive scepticism over a shorter time in the future?*

By engaging with its everyday, hands-on, and 'sensuous, unspoken, and often hidden dimensions' (Pink, 2021: 199) the workshop facilitated new pathways for thinking Digital Water otherwise. Herein lies also the workshop's critical potential: it made space for alternative voices beyond the dominant narratives of 'objectivity' and 'human factors'. These voices tell a story about the sometimes surprising productivity of bringing hands-on 'gut' knowledge in the same room with theoretical, 'objective', and calculative logics of data to talk about shared ways of making sense of water. While these positions may seem separate from each other, I have shown that doing smart water management in practice requires a deeper understanding of how they intertwine, augment, and validate each other in practice. In this sense, collaborative spaces for shared explorations of human and digital sensing and

sensemaking practices – both calculative and experiential – hold the potential to develop ‘smart(er)’ water management in practice.

The next chapter, adapted from a scientific article that I published with Adrienne Mannov and Astrid Oberborbeck Andersen, shifts our scale of attention one final time before I conclude. It offers a playbook – a set of instructions – for how to collaborate across disciplinary knowledge tensions productively by crafting ‘physical spaces for shared intellectual exploration’. It takes the insights from the practical workshop and theorizes ways to open space for a critically engaged open-systems ethnography.

Chapter 7. Tensions Across Disciplines

There is a sense of expectation, anxiety, and excitement in being on the verge of starting something new. Being tense is often associated with a sense of worry or nervous strain. But tension can also be productive. It is with these feelings that I meet my new colleagues – control and systems engineers, with the participation of cryptographers – in the project laboratory of the Smart Water Infrastructures project (SWIft)[10]. It is a modular test facility developed for the SWIft project. It can be configured to emulate a variety of scenarios within water distribution networks such as water leakage, sewer overflow, or cyberattacks. At the SWIft Lab, my colleagues perform water management experiments to try to solve those challenges through computational and algorithmic technologies. Beyond a handful of engineering Ph.D. students and Postdoctoral fellows who, like me, are at the beginning of their academic careers and thus concerned with performing at best within their disciplinary boundaries, the project team consists of four work-package leaders, including Astrid, my supervisor, and two Principal Investigators (PI). One of the PIs, Rafal, is a theoretically oriented system engineer, mathematician, and cryptographer. The other, Carsten, is an industrial professor in electronic systems who specializes in digital water management and automation. Carsten played a particularly active role in mediating between the engineering and anthropological perspectives of the project. Apart from mediating between the academic disciplines, he also contributed to mediating between science and the 'applied world' through use cases and collaborations outside

[10] The laboratory facilities were funded by the Poul Due Jensen Foundation for the SWIft research project in 2017 and the laboratory was fully functioning at Aalborg University in 2019.

of the SWIft Lab and the university with the industry and different water utility companies. This particular link formed a generative sensitivity towards anthropology. It is this link, or tension, between computational engineering and anthropology, that I explore in this chapter.

At this first meeting, I learned that the predictions of the algorithmic models developed by my colleagues normally work on assumptions which, they admit, do not always hold true outside of the laboratory. My engineering colleagues struggled to develop algorithms that fit with the messiness of actual water management practices and human decision-making processes. Thus, they refer to human activity as 'noise' since it interferes with the potential and optimal work of computational and automated solutions. The digital solutions that they develop are therefore based on assumptions about how a water utility is run in practice, how water utility employees prioritize time and resources, their equipment, and decision-making processes. Because the SWIft project aims specifically at developing new water management solutions to be employed in practice, this was a challenge. To deal with this challenge, my colleagues wanted to develop a 'primitive data model on human behaviour', and they expected my ethnography to provide 'knowledge on human behaviour in specific situations and contexts', which they could then compute into their algorithms. With these empirical insights, my colleagues expected to be able to train new and more accurate data models that would better fit the actual needs and challenges of water utility companies. This was very distant from my research approach, which aimed at showing the inherent complexities of Digital Water in practice. So, already at its onset, the SWIft project was filled with interdisciplinary tension. On the one hand, I worried that the epistemological and disciplinary gap that separated me and my colleagues could not be overcome without

compromising the quality and richness of my ethnographic data. From my viewpoint, the ethnographic richness that I had encountered during fieldwork could hardly be boiled down to predictive data models. On the other hand, my engineering colleagues found it hard to see how ethnography would contribute to the overall project if it could not. These concerns accompanied me throughout my fieldwork and generated useful reflections that led to stimulating analytical dilemmas. How could I retain the explorative and critical character of anthropology, while productively contributing to a mutually enriching collaboration within SWIft? Could our different disciplinary positions make up a productive tension?

Along with these concerns, I also brought other questions with me into fieldwork. These also originated from my meetings with the SWIft team. Specifically, my colleagues were interested in learning how decisions about water leakage detection and asset management are taken by water utility operators and engineers in practice. They wanted to know about the kinds of technologies and forms of knowledge and expertise that water utility operators employ to detect ruptured, leaky, or otherwise dysfunctional pipes and water supply systems. In this chapter, I elaborate on what it takes to collaborate across anthropology and computational sciences, and what role ethnography can play in such collaborations. What follows is an adapted version of the second and final scientific article that I chose to include in this dissertation. The article, which I co-authored with my supervisors, Adrienne Mannov and Astrid Oberborbeck Andersen, is entitled 'Ideal-Real-Actual. Models *for* Collaboration Between Anthropology and Computational Sciences' and published in *Anthropology in Action*, Volume 30, Issue 3 (2023).

Article B.

Ideal-Real-Actual
Models *for* Collaboration between Anthropology and Computational Sciences[11]

Jonas Falzarano Jessen, Adrienne Mannov &
Astrid Oberborbeck Andersen

An e-mail arrives from the Smart Water Infrastructures Lab at Aalborg University: 'I think we found something you can add to the questionnaire'. Puzzled, but intrigued, I (Jonas) arrange a meeting. A couple of weeks later, my colleagues – an engineering PhD student and a professor and 'maker of algorithms' (as he likes to call himself) with doctoral degrees in mathematics and engineering – introduced me to the basics of 'game theory'.

The engineers and I are colleagues in a cross-disciplinary and engineering-led project, Smart Water Infrastructures (SWIft), which works to optimise water flows and management by developing algorithms and automation technologies without compromising data security and privacy. From its onset, ethnographic observations about the socio-technical aspects of such systems were seen as vital to the project. The hope was that these insights would help foster a sense of ownership, expertise, and trust in automation among water

[11]This chapter is adapted from the scientific article of the same name and published as: Jessen, J. F., Mannov, A., & Andersen, A. O. (2023). Ideal-Real-Actual: Models for Collaboration between Anthropology and Computational Sciences. *Anthropology in Action*, *30*(3), 9-19. doi:10.3167/aia.2023.300302

utility personnel in Denmark and integrate actual utility practices that would enrich the technical research.

With game theory as a shared frame of reference, my colleagues were suggesting that I collect empirical data about decision-making processes at water utility companies, which they could then model into their predictive algorithms. They were trying to reach across the methodological and epistemological divide between our disciplines, and I saw game theory as an invitation to create a shared space of practice in which ethnography could contribute to their development of algorithms. But how might we transform the ethnographic richness of my data material into the kind of contribution that the engineers were imagining? And how could game theory productively engage with and contribute to their epistemic practices, without compromising the ethnographic quality of my work?

This article presents reflections on cross-disciplinary collaboration between us – Jonas, Adrienne, and Astrid (three anthropologists) – and computational engineers during two consecutive research projects. Both projects aimed to optimise resources in electronic and digital systems by automating them, while simultaneously developing methods that secure dataflows and privacy. Our colleagues are mathematicians specialising in cryptography and engineers working in the field of systems, control, and automation. For practical reasons, we refer to them as computational engineers throughout this article.

Some Background

These research collaborations began in 2017 with the formulation of the first research project (SECURE) and run until 2024 when the second project

(SWIft) ends. Both projects are engineering-centred and led. The SECURE project (2018–2021) worked to further develop optimised and secure computation through a cryptographic method called Secure Multiparty Computation (MPC). The second project is the ongoing SWIft project (2021–2024) from which the opening vignette originates. SWIft focuses on the development of smart water infrastructures for more efficient water management at water utilities while also employing secure computational methods. 'Smart' is the idiom used by our engineering colleagues to refer to technologies that are responsive and somewhat automated, based on the computation of large datasets.

In this article, we show how participating in cross-disciplinary research projects with computational engineering is not enough to make fruitful collaborations happen. It takes the crafting of extra-ordinary spaces of shared practice, and new conceptualisations to actually *alter* disciplinary boundaries. We argue that an altering of disciplinary boundaries in collaborations between anthropologists and engineers can happen when there is (1) a shared project, (2) a practice of engaging with one another's theoretical universes, and (3) physical spaces for shared intellectual practice. The research is still ongoing, and so is our thinking about these shared modes of collaboration. For this reason, what follows will focus on how the first two elements of this triplet have led us to experiment with designing the third. For now, let us simply clarify that when referring to physical spaces, we mean both regular meetings, seminars, conference participation, workshops, or laboratory experiments. By design, they allow for ongoing conversations and co-creation across disciplines, which can lead to a curiosity about and engagement with each other's theoretical logics. This triplet for collaboration, we suggest, is not only a model *of* our teams' cross-disciplinary

collaborations but also holds the potential to become a model *for* (Geertz, 1973: 93) practice in teams working across anthropology and computational engineering.

In his influential study of religion as a *model of* and a *model for* reality, Clifford Geertz defines religion as a system of symbols that provides its practitioners not only with a symbolic representation – or a *model of* – the general order of reality but also with a blueprint – or a *model for* – practice (Geertz, 1973: 90-93, 127). To explain, Geertz refers to the example of a dam: A theory of hydraulics, he suggests, helps us understand how dams work. It acts as a *model of* reality. But hydraulic theory also assists the construction of a dam. In this case, theory serves as a *model for* reality (ibid.). Geertz emphasises the analytical richness of moving back and forth between those two perspectives the symbolic and practical – in the interpretation of ethnographic phenomena (Geertz, 1973: 121-123). Similarly, we suggest a blueprint for how to collectively 'tack back and forth' (Helmreich, 2009; Mannov et al., 2020) between a different set of *models of* and *for* practice, namely, what Mannov et al. refer to as the *ideal*, the *real* and the *actual* (Mannov et al., 2020). As we shall see, this framework has helped us articulate and collectively navigate the complexity that ethnographic insights from *actual* empirical settings bring into a cryptographic world that is otherwise populated by theoretical *ideal* models, against which imagined *real* case-scenarios are measured.

By drawing on our collaborations with computational engineers in the SECURE and SWIft projects, we do not only wish to respond to this Special Issue's call for 'productive interferences' in cross-disciplinary endeavours. We also wish to make an intervention into how anthropologists and

computational engineers might think and work together by applying the relation between *ideal, real,* and *actual* as a blueprint for the crafting of physical spaces for shared intellectual practice.

With the growth of 'ubiquitous computing' (Dourish & Bell, 2011; Mackenzie, 2017) anthropologists and other social science and humanities scholars have studied the social life of big data and computing in a variety of contexts. Some have addressed the risks that AI, big data, and automation pose to the sustainability of social lives (boyd & Crawford, 2012; Dourish, 2016; Fisch, 2013; Lustig et al., 2016; Mackenzie, 2015; Philip et al., 2012; Richards & Hartzog, 2019; Seaver, 2018b; Taylor, 2017; Zuboff, 2015). Others have attended to the practices and logics of data scientists in different contexts (Breslin, 2022; Lowrie, 2018). Knox and Walford highlight 'the potential of ethnographies of digital technologies to disrupt anthropological ways of thinking and doing' (Knox & Walford, 2016: 2). They see the digital as an opportunity to alter disciplinary practices from within anthropology. Yet, most anthropological research on 'the data moment' (Douglas-Jones et al., 2021; Maguire et al., 2020) has focused more on how to practise anthropology as a critical discipline in a digital era and less on the potential and challenges of bringing anthropological insights (big, quick, algorithmic, or thick) to work in collaboration *with* data scientists and the technologies they develop. Recognising that working *with* shifts the ethics of ethnography, we aim to contribute to a critical anthropology in action with computational sciences. We situate our arguments alongside critical data studies and 'machine anthropology'—an umbrella term covering scholarly practices that venture into direct collaborations with data scientists (Blok & Pedersen, 2014; Madsen et al., 2018; Seaver, 2018a) or that develop digital ethnography approaches with big data (Munk et al., 2022). How might

anthropology and related disciplines contribute positively to and work with technologies that are being deployed as tools that – in addition to optimising resources and profits – also offset and manage the negative effects of, say, climate change and other major challenges of the Anthropocene?

We begin with some background from the SECURE project that focused on data security and optimisation and involved some of the same computational engineers that we encountered in the opening vignette of this article. Here, our productive interference began as an empirical insight: how computational engineers understand their theories and models through notions of *ideal* and *real*, and how we used ethnography not only to gain insight into their epistemic framings but also to reach across the scientific divide between us, by introducing the *actual*. Even though our focus has changed from data security to optimisation in water management, we begin by suggesting that these insights – *ideal-real-actual* – can act as a blueprint for interaction with our colleagues in the SWIft project. Thereafter, we show how our colleagues reached out to us with their own epistemic framings – namely, game theory – as a way to embed ethnographic insights in our shared project. By letting game theory inform our ethnographic attention, we show how ethnographic insights can be made legible for our colleagues but also where limitations occur. We conclude by showing how this approach is not only a *model of* how we collaborate across scientific silos but may also function as a *model for* further collaboration for like-minded scientists from anthropology and engineering.

Ethnographic Explorations of *Ideal-Real-Actual*

Our first collaboration with the computational engineers began with the SECURE project. As we have written elsewhere (Mannov et al., 2020),

collaboration across disciplines requires trust and relation-building over time. This was where the idea of the triplet – a shared project, an engagement in each other's theoretical universes, and spaces of shared intellectual practice – emerged as a collaborative and theoretical device. The idea for the shared project across engineering, cryptography, and anthropology originated with Professor Rafal Wisniewski. Andersen was approached by him because, as he said, he did not know how to make people act properly in smart and automated systems and he needed a discipline familiar with human behaviour. This resulted in a successful research proposal with disciplinary work packages and a shared project. But that was not enough. The SECURE team met regularly for research meetings, but we remained firmly in our disciplinary silos. We also held a series of workshops during the project's three years in which more time together was allocated and the meeting structure was more flexible. Within those shared physical spaces, we were able to ask dumb questions (Verran, 2013: 156) of each other, debate our scientific epistemologies, and become familiar with each other's ways of theorising (see Andersen, Astrid Oberbeck et al., 2021). It was in these workshops that our understanding of the computational engineers' *ideal* and *real* could be explored empirically. This led us to offer up a third analytical framing that our colleagues seemed to be missing in their work: the *actual*.

The *ideal* in cryptographic models refers to secure computations done by a central 'trusted third party'. Here, all parties in a network send their sensitive data to a third party who does the computation on behalf of the collective, sends only the result back, and does not disclose the sensitive data to any party. This way, the collective gains the benefit of a shared analysis without ever disclosing data other than to the trusted third party. This is referred to

as *ideal* because this model assumes that the third party is not corrupted and is fully trusted. All other computational methods are measured against this *ideal* (Mannov et al., 2020: 38). This is where the cryptographic notion of *real* comes in. Here, secure computation methods are used, such that all parties have the benefit of a shared analysis of sensitive data, without disclosing this data to one another, and significantly, *without* using a trusted third party. The data is computed within the collective, also called decentralised computation. The robustness of such methods, whether they be MPC, fully homomorphic encryption, zero-knowledge proofs etc., are measured against this *ideal* (see e.g., Lopez-Alt et al., 2011). Such methods were referred to as *real* not because they took their point of departure in actually existing empirical settings, but because they were imagined *real* settings, models populated by cryptography's usual (fictitious) characters, such as *Bob*, *Alice*, *Mallory* and *Eve* (Mannov et al., 2020: 39).

The computational engineers struggled to further develop these existing methods because when they tested *actual* data in their new decentralised protocols, they did not compare well to the *ideal*. The problem was that they were not making a distinction between the *real* methods and the challenges of working with *actual* data. These two worlds were very different. It took lots of questioning from the anthropologists to realise that their colleagues' *real* was in fact, still theory. *Bob* and his friends were just points on a graph, not actual actors (outside of theory) in the empirical world who wished to compute their data. As demonstrated in the SECURE project's Science TV in the Cryptic Commons exhibition (see source, Figure 17), the *actual* became a helpful term and was adopted into the mathematician's and engineer's language:

Jaron (mathematician): But the problem is that even though we can show that the protocol, in this situation [b], is as secure as in this [a], then it might not actually be as secure as when we have this 'actual world' here [c]. So, that's the reason why we need to maybe come up with a new way of defining (...) what is security, because we might not be able to achieve this situation [a], when we have a situation like this [c].

Qiong Xiu (engineer): ...from the engineering side, or more applied side, what I found is their [ideal world (a)] is actually unachievable. It's (...) impossible to achieve (...) what we in engineering can do and what the mathematicians assume in the 'ideal world'.

Jaron: I actually found this problem very interesting. When I was talking to Qiong Xiu (...), it seemed like there was a gap in the literature. (...) So, I think that we have to, kind of, redefine what 'ideal' is. If this is their actual world – that we do not have this full connectivity – then I think the theory should be made such that it fits the 'actual world'.

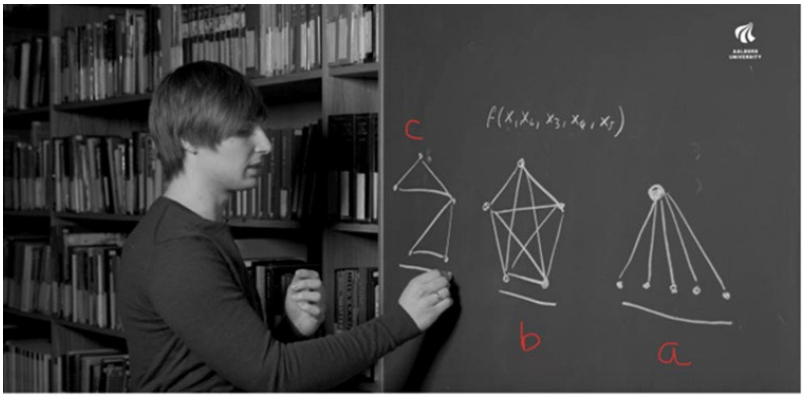

Figure 17: *Jaron Gundersen explains the difference between the ideal (a), real (b), and actual (c) world as they came to be used in the SECURE project. From: 'Graph Topology. Ideal versus real world between mathematics and engineering' (Mannov et al., 2021)*

Our colleagues had not used the term *actual* before our collaboration, and it does not exist in the cryptography literature. That the graph is not fully connected (c in Figure 17) on the 'more applied side' as Qiong Xiu explained, was a practical problem of the theory not corresponding to the empirical settings. By digging into our colleagues' theoretical universe, we were able to offer terminology that helped them express their problem and address it. The addition of the *actual* to our colleagues' *ideal* and *real* became a *model of* the insights that the SECURE project generated together. However, because the next project, SWIft, faced similar challenges of how to collaborate across disciplines, we found it useful to transfer insights from *ideal-real-actual* to the work with computational and automation technologies in the new project. With this move, *ideal-real-actual* came to function as a *model for* this collaboration, as well.

The Engineers Want to Play

Let us return to the game theory meeting. At the time, Jonas did not exactly know what game theory was beyond what he had seen in the movie *A*

Beautiful Mind (Howard, 2001) about the Nobel Prize-winning economist John Nash, nor did he know how it could be applied to water management. At the meeting – a shared space in the project – he understood that our colleagues were developing and modelling algorithms that would allow them to calculate and predict optimal water management practices. In social sciences and economics, game theory rests on the assumption that 'instrumentally rational agents' act in an optimising and strategic way to satisfy given and well-defined objectives (Heap & Varoufakis, 2004; Tesfatsion, 2017). It provides a way of *describing* the rationales that drive decision-making practices among 'rational' actors in, for example, water management at specific water utility companies and enables predictions about human decisions for the achievement of a shared agenda (Marden & Shamma, 2015: 862-866). By contrast, game theory is also perceived by some engineers as a 'suggestion' of how actors in the water sector ought to manage water flows, considering the sometimes conflicting agenda and strategies of decision-makers. This is referred to as a *prescriptive* model (ibid.). In other words, game theory seeks to either *describe* the most probable decision taken by rational actors given the knowledge available to them or to *prescribe* the smartest strategy available to each 'player' to achieve a shared desired outcome. This outcome is referred to as *equilibrium* (Heap & Varoufakis, 2004: 41-45; Nash, 1951). Our engineering colleagues sought an equilibrium between the *ideal* practice – what is theoretically feasible in an optimal best-case scenario – and what they addressed as *real* practices, that is, models of computable and generalisable insights based on how they imagined water management negotiations take place in *real* life.

Our colleagues' explanations and Jonas's subsequent reading of game theory pointed to several ways in which we were working together. Firstly, our

colleagues invited us to engage in their theoretical universe, an invitation that required us to think about our scientific practice anew. Secondly, our insights from the SECURE project helped us navigate the computational engineers' logics in game theory. One layer was described as computationally 'optimal', or *ideal*. But this did not consider the social context. The next level was how our colleagues envisioned the ways in which *descriptive* data (Jonas's 'questionnaire') about utility workers' decision-making and how they could include this in their model. This reminds us of the cryptographers' *real*. The idea was that data could be generalised and embedded in a model, rules could be established, and *equilibrium* could be reached. But as soon as situated and thick ethnographic data from *actual* practice is inserted into a model, its context is lost. For us to communicate this concern to our computational colleagues, it was important that we agreed on these different layers when engaging with game theory.

It was clear that our colleagues were already thinking with *ideal-real-actual*. For example, they were developing a model in the laboratory for *ideal* control in water distribution networks (Misra et al., 2023), and they were also planning on embedding this model with generalised data from *actual* decision-making processes and practices at water utilities. But, as Jonas explained to them, the kind of *predictive* decision-making and *equilibrium* that is inherently embedded in their understanding of game theory is quite distant from how situated practices and agency (read: the *actual*) are understood in anthropology. Many questions remained before *ideal-real-actual* could function as a *model for* our collaboration. Could we translate *actual* ethnographic material into computable, quantitative *real* models? And what would happen to the inherent richness, complexity, and contradictions of the ethnographic *actual*, when it became a

part of the game theoretical *real*? From his interactions with the computational engineers on the SWIft team and the fieldwork he had been doing at a water utility in western Denmark, Jonas knew that he could not simply 'collect' generalised decision-making practices among utility workers, to be implemented into a game theory model. There were many complexities and situational nuances in the decisions he observed, so, if he was to let game theory inform his ethnographic attention, he needed to find a way to understand and work with these complexities.

Jonas decided to start from the insights that our colleagues wanted to compute in their models; namely what they expressed as 'human specificities on decisions' or, as they elaborated, 'what people in specific situations and particular contexts assess as high-priority and low-priority factors or interests, in a situation where there are conflicting interests'. During the meeting, our engineering colleagues had raised questions like: 'Which reflections have moved the decisions that agents in the water sector take? How have project managers gained the knowledge that they possess? How do they use such knowledge? What factors influence their assessments?'. These questions are well-suited to ethnographic methods, and they accompanied Jonas during the next months of fieldwork.

Water Utility: Situated Negotiations of Ideal-Real-Actual

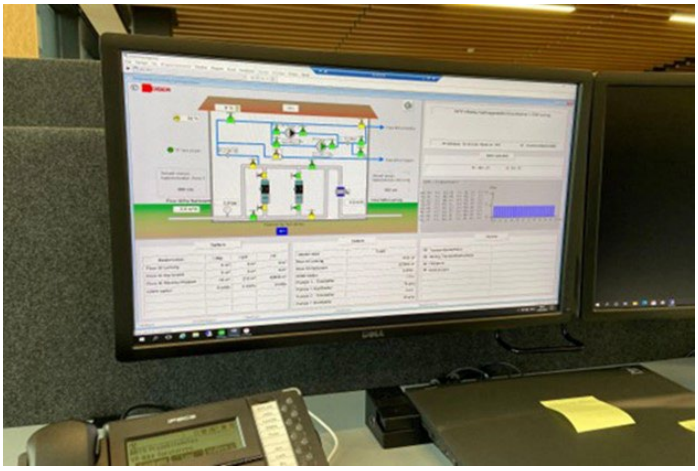

Figure 18: *The SCADA system, with a real-time overview over the functioning of a pumping station managed by the water utility of Lemvig. Lemvig, August 2021. Credit, Jonas Falzarano Jessen*

As an indirect consequence of the Danish Water Sector Act (Water Sector Reform Act, 2009) passed in 2009, several minor Danish water utility companies had been compelled to either close or merge with neighbouring utilities. This was the case for the water utility of Thyborøn-Harboøre in western Denmark, which was merged with the utility of Lemvig when Jonas started his six months of fieldwork there. Jonas learned that the management had recently decided to transition to a new SCADA system, a kind of graphical user interface (see Figure 18). The SCADA provides an overview of the total system of pipes and pumps in the utility infrastructure and allows the employees to supervise how water moves through it. In addition, the SCADA interacts with the computers that control and automate specific processes in water management. According to the employees, the transition to the new SCADA system was mainly a managerial decision to simplify operations across the newly merged utilities. Brad, the technical coordinator

of water meters at the utility, explained: ‘From an operations perspective, they are both quite intuitive and very similar to each other’. The 20-year-old SCADA system used in Lemvig still worked. For the majority of the employees, it had been their primary digital tool since they had started working there. So, why get rid of it?

The Ideal Is Not Ideal

The new system had one key functionality that the old one did not: its controlling unit is more easily accessed and the processes and automation that it runs can be adjusted according to new needs or circumstances at any time. According to Frances, the Chief Operations Engineer at the utility, the old system ‘was not programmed correctly’. In addition, he explained, it ran through:

> *An optimised management system on our pumps that we cannot control. It's all computed into this automated ‘optimization’ that we cannot access. (...) And while I really think that we would be able to make those pumps work more efficiently if we could programme them ourselves, we are bound by the fact that they are designed to be automatic and autonomous, so we cannot adjust the software! (...) I am sure that what the company has designed is ideal in terms of the assumptions it is based on. But it's just that I don't quite agree with some of those assumptions about how the pumps should run. Their energy consumption is just too high.*

When Frances spoke about ‘programming’ the new pumps, it seemed like this might be a place where the decision-making agenda could be of game theoretical interest.

The transition to the new SCADA offered a rich opportunity for the utility employees’ otherwise unarticulated considerations to surface. This offered Jonas an opportunity to ethnographically explore how decisions about water management practices were debated, negotiated, challenged, and assessed, and how doubts, situated practices, and experience informed the employees’ decisions about which smartification and optimisation practices to adopt. In addition, the discussions and negotiations taking place around the new SCADA seemed to reflect the layers in *ideal-real-actual*. In the *actual* everyday practice of water management at the Lemvig utility, the old SCADA lacked the flexibility that would allow for the contextual decision-making that was required for the system to run optimally. The system was made in relation to an *ideal* scenario, which did not fit Lemvig's specific situations, nor did it reflect its current priorities in terms of water management. Frances's criticism spoke directly to our insights about the cryptographic *ideal*, which was based on the assumption that total computational security could be achieved. Similarly, the old SCADA system was based on theoretical assumptions about efficiency, optimisation, and automation that did not take *actual* contexts into account.

Game theory had redirected Jonas's attention to negotiation and decision-making and the distinctions in *ideal-real-actual* helped him identify the complexity of a new computational and digital system. First, the conceptual distinction describes the kind of world phenomena with which we were involved. In this sense, ethnographically rich data – which in the eyes of

engineers is often fluffy and too messy to work with – when seen as the *actual* world, becomes legible to our computational engineers because it is integrated into the logics they work with. Secondly, *ideal-real-actual* explains the kinds of problems that often emerge when generic technologies designed in a lab – as *ideal* or *real* – are implemented in *actual* complex contexts.

Hands-On Actual

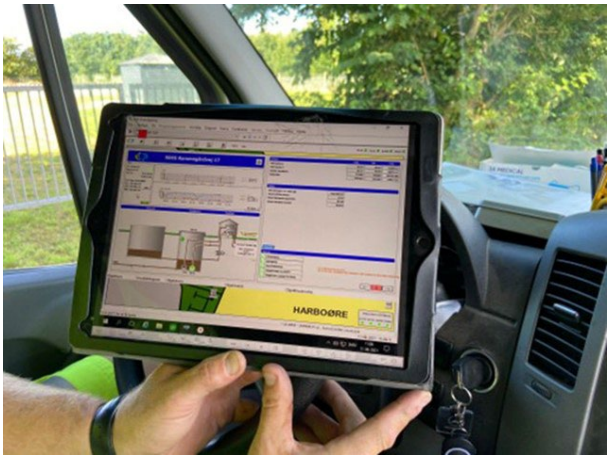

Figure 19: *The SCADA system displayed on a tablet in the field. Lemvig, August 2021. Credit, Jonas Falzarano Jessen*

Some employees have worked at the Lemvig utility for decades. They know the flaws and strengths of the piping and pumping network like their own back pockets. Brad is one of them. He used to operate the utility's water meters in the field. In the meantime, he received further training and is now responsible for the oversight of the whole system's pressure and flow of water through the SCADA system. In close collaboration with the utility engineers, he follows the current state of the physical network and its water flows and assesses whether or not the system works optimally (see Figure 19). Based on

his experience with the SCADA and the daily and yearly rhythms of the local communities' water consumption, Brad monitors water consumption patterns and pressure and flow-graphs from the pumping stations that the utility manages. He does this to identify what he refers to as 'irregularities': potential leaks and damages in the network, which he then investigates in the field (see Figure 20).

Figure 20: *Brad, interacting with one of the physical controlling units supervised by the SCADA system. Lemvig, August 2021. Credit, Jonas Falzarano Jessen*

This requires technical skills, a deep, situated knowledge about the local neighbourhoods – how they consume water and for which purposes – and an eye for how global and geopolitical circumstances manifest locally. For instance, it is key for Brad's work to know which areas of the local community are affected by population fluctuations due to tourism. He knew which industrial areas use water as part of their production and when and which scarcely populated areas are made up of farmland that require sudden and large amounts of water for irrigation due to a changing climate. This was

important contextual information that helped him understand what should be interpreted as an 'irregularity' and what should not. As Brad explained: 'Normally, the fishermen consume a lot of water by the harbour when they come back and start to clean up their ships and catch. But in the past two months, their consumption has been close to zero (...). Since the war in Ukraine started, it [the diesel] is too expensive for them to go fishing'.

With the fully automated and old SCADA system, Brad's situated knowledge remained external to it. He could make suggestions about how to react to problems based on his hands-on knowledge, but it was not integrated in the SCADA because the system could not incorporate that kind of situational information. Regularities in consumption patterns are easily modelled into automated systems. Irregularities, however – such as extreme weather events, geopolitics, market changes, and infrastructural breakdowns or damages – are hard to model and predict. Whenever Brad identifies such potential irregularities, he consults with his colleagues to assess his judgment before deciding how to react. These colleagues are engineers who can make theoretical calculations that help him make the right decision, but he also consults fieldworkers and operators. 'They [field workers and technical operators] usually know what is currently happening in the area. Some of them even remember if some water taps have been installed incorrectly and which service connections are in bad condition', Brad explained. They are the ones with extensive knowledge about the neighbourhood and the people, pumps, valves, and pipes that populate it.

Brad and his colleagues' situated knowledge of the conditions and the seasonal rhythms of the community lead to a particular kind of decision-making and negotiation. They are based on the iterative relationship between

day-to-day circumstances and the models that are embedded in the SCADA system. This is part of what the SWIft engineers were looking for in the game theoretical 'decision-making practices'.

Getting Real

Brad's work is an example of how decision-making processes at the utility function through a feedback loop between different layers of knowledge. Those ways of knowing derive from *real* descriptions – that is, models based on imagined real-world scenarios and needs that are built into the SCADA system – but they are always interpreted against the backdrop of inherently situated knowledges about the local surroundings: They are evaluated through *actual* observations from the sensed physical world.

This feedback loop functions the other way around, too. As the utility transitioned to the new SCADA system, Frances saw this as an opportunity to re-evaluate the (infra)structure of the system, asking: 'Is there anything that we can do differently to avoid having to change the physical infrastructure, without compromising the efficiency of our water supply?' He wanted to incorporate Brad's hands-on reading of the SCADA – his situated practice that requires complex and local knowledge – into the new system. During this evaluation, key suggestions for how to change the infrastructure came from *actual* observations made by experienced fieldworkers and network operators who knew the physical system and its context inside-out. This informed the solutions developed by the engineers at the utility. In other words, *actual* observations were generalised and inserted into the new SCADA, making them a *real* model for optimisation at the utility. The *actual* had, in other words, become *real*, since certain observations were considered to be *likely* to occur, and therefore generalisable. They could be

integrated into the system in a way that was truer to the *actual* lived circumstances in the municipality. This testifies to how the boundaries and relationship between the *actual* and the *real* are continuously blurred, negotiated, and reworked in practice. Nevertheless, the utility employees knew that there would be situations that could not be predicted in a model. The *actual* remained relevant, and the new system needed to be flexible enough to consider situated elements outside of it, as well.

Jonas needed to bring these different layers of knowledge back to the SWIft engineers. It was not just a question of collecting 'decision-making practices' to develop – in game theory jargon – *descriptive* models that could be reworked as *prescriptive* models, or *actual* observations that could challenge the imagined *real* of our engineering colleagues' models. He needed to show the multiple layers – *ideal-real-actual* – in these practices, as well as the recursive relationship between them. Otherwise, the SWIft engineers risked reproducing a new system that, in Frances's words 'was not programmed correctly'.

Reworking Boundaries

The project is still ongoing, but we would be remiss not to close with a description of how some of the insights presented in this article have been put to use in smart water management systems currently being developed. Early in 2023, the employees of five different Danish water utilities, representatives from a Danish water management consultancy, the SWIft research team, and half a dozen ethnographers and colleagues gathered for a one-day workshop on 'Human and Artificial Intelligence in Future Water Systems'. The purpose of the workshop was to craft a space where utility operators, consultants, researchers, and algorithms could interact with and inform one another

through *actual* cases, but in a future-oriented manner. It marked the conclusion of six months of research collaboration between anthropologists (the authors), our computational engineering colleagues at SWIft, and a handful of engineering consultants. The insights presented in this article served as the workshop's analytical framework. Informed by the relational recursivity of *ideal-real-actual*, the workshop participants worked together with the idea that automation and control algorithms could be improved by incorporating *actual* world scenarios that included human skills and sociality. The interdisciplinary and trans-sectoral workshop was yet another physical space that made valuable insights and moments of serendipity possible.

In close collaboration with our engineering and consultancy colleagues, we designed the workshop around three interconnected stages. The first stage consisted of a laboratory exercise in which our computational engineering colleagues assisted the participants in engaging with water management software developed as part of the SWIft project. The second stage was a mapping exercise where water utility operators portrayed how digital and physical infrastructures affected their daily work in the field. Finally, the third stage engaged all the participants in a shared discussion about how future water management practices could be made socially intelligent. The three stages allowed for different layers of knowledge to emerge and interact. The *real* of a laboratory experiment was tested and evaluated through the *actual* working habits of the various utility operators. The *actual* of the current digital and physical infrastructures was held up against the *real* of the imagined futures of the different water utilities. Finally, the *ideal* was reworked in terms of the shared imaginaries, needs, and situated knowledges present at the workshop.

Through our ongoing collaboration over the course of six years (2018–2024) and two consecutive research projects, the altering of disciplinary boundaries was enabled through a shared project, by engaging with each other's theoretical and epistemological universes, and by creating physical spaces for shared intellectual practices. Game theory – although not in a linear and straightforward manner – helped alter our anthropological practices by creating a conceptual space for a shared intellectual endeavour. Jonas used the distinction between the *ideal,* the *real,* and the *actual* to help him attune his ethnographic attention to processes and practices of decision-making and negotiation in relation to game theory logics. This made it easier to connect the observations made in the field – the *actual* world – with the *ideal* and *real* work carried out by our computational engineering colleagues in the smart water lab and around the SCADA at the Lemvig utility.

Drawing on Clifford Geertz' famous distinction between religion as a *model of* and *for* practice, we have suggested that adding the *actual* to the distinction between the *ideal* and the *real* world – understood as orders or levels of reality in which computational engineers and data scientists do their work – anthropologists can gain an epistemic space for contributing to work carried out in data science. We have proposed the *actual* – the space of ethnography, where lifeworlds unfold and are experienced in unexpected ways – as a concrete anthropological tool, intervention, and contribution that attunes computational scientists to the lived worlds into which they increasingly intervene and change. Further, we have shown how *ideal-real-actual* became a way for anthropological insights to become legible to computational engineers and gained currency in the development of optimisation algorithms and computational technologies. As the workshop

exemplified, the *ideal*, *real* and *actual* are unstable orders, as they intertwine, change character, and inform one another in different situations and contexts. Attention to how the *actual* informs the *ideal* and *real* in the development of computational technologies holds the potential of not only optimising the work of computational engineers and data scientists but also of making it more socially accurate and just. In this way, the *ideal-real-actual* functions as a generalisable model *for* collaboration across anthropology and computational sciences.

Chapter 8. Conclusion

With this dissertation, I have investigated the emergence of Digital Water as an open ecosystem in a critically engaged and collaborative way. Over 12 months of ethnographic fieldwork among water utility employees, researchers, state officials, and water technology producers, I studied how Digital Water and different future aspirations, relations, and practices for water management in Denmark mutually shape each other. Within this framework, my primary concern was to explore how Digital Water reconfigures ways of sensing, making sense, and enacting water, water data, and their underlying infrastructures in practice. To do so, I was particularly attentive to three empirical tensions that bring attention to different aspects of Digital Water, namely the tension between diplomacy and export, between human and digital forms of sensing and sensemaking, and between anthropology and computational science. I have categorized these tensions as diplomatic, operational, and disciplinary. The general thrust of my argument has been that engaging ethnographically with these tensions offers a vantage point into the ways in which Digital Water reframes how global water infrastructures are commodified, managed, and understood. Digital Water offers, I argue, an ethnographic vantage point into the current state of Danish Welfare and its increasingly neoliberal and calculative character. Additionally, through the planning and facilitation of an interdisciplinary and collaborative workshop with computational scientists and water professionals from within and without academia, I demonstrated how a critical and engaged ethnography can take part in shaping Digital Water futures.

I approached Digital Water through four levels of engagement: as 1) an empirical and discursive phenomenon which has 2) transformative material and practical implications within water management that offer 3) anthropological insights into the current state of Danish Welfare and 4) generate perspectives on ethnography as a collaborative, interventionist, and future-oriented practice in trans-disciplinary collaborations. In the following, I digest these levels of engagement one by one to bring the different contributions of this dissertation to the fore.

Digital Water as an empirical and discursive phenomenon.

In Chapter 2, I have shown how the idea of Digital Water emerged discursively around intertwined promises of ecological relief and economic profit. I discussed how these promises gain currency through the work of international interest organisations such as the IWA before they trickle down and are adopted (and adapted) by national and local actors in Denmark, whom I referred to as Digital Water pioneers. Furthermore, I have shown how these promises are held together by the idea of digitalization, or 'smartness' as a pathway for the betterment of water and monetary flows within the Danish water sector. This dissertation contributes to emerging literature in social sciences and humanities on Digital Water and its social implications by moving beyond a discursive level and showing how Digital Water materializes in practice in Denmark.

Digital Water has transformative material and practical implications within water management.

Through ethnographic engagement and by reference to the Danish 'Export Strategy for Water' (The Danish Government, 2021), I have shown how Danish water utility companies function as national platforms for the

international showcasing of Danish water solutions for export. In Chapter 5 and the scientific article that it builds upon (Article B), I followed the work of another materialization of Digital Water in the figure of Liam, the Danish water ambassador at the Royal Danish Embassy in Rome, Italy. I showed that the water ambassador contributes to the commodification, scaling, and export of Digital Water through what I call 'Water Diplomacy'. I used Water Diplomacy as a concept to describe how the water ambassador uses narratives of Danish exceptionalism to build new international relations, make Digital Water scalable, and export Danish water technologies. I argued that this process of commodification and export is enacted by the water ambassador through the crafting and strategic scaling of narratives of Danish exceptionalism within water management, digitalization, and sustainability.

Another practical implication of Digital Water concerns the ways it affects relations between machinic and human forms of knowing, experiencing, and acting at water utility companies. In Chapter 6, I explored what digitalizing water means in practice on a hands-on level and how it is experienced by water utility employees in Denmark. Based on a thick and playful description of water leakage detection practices at Lemvig Water, in the first part of the chapter, I show that water management, despite the uptake of seemingly 'objective' digital data-based systems, is inherently sensuous and intuitive work just as much as it is practised through forms of 'calculative rationality' (von Schnitzler, 2008: 901-902). By getting close to the everyday practices of Brad, a water utility operator at Lemvig Water, I showed how digitalization shifts how water utility operators make sense of water infrastructures and the flows of water, data, and other kinds of information that make them legible and actionable. I argued that water management ultimately takes place

through integrated human and nonhuman modes of sensing, sensemaking, acting, and responding.

Digital Water offers anthropological insights into the current state of Danish Welfare.

Looking at the digitalization of water management through the lens of different sets of tensions between diplomacy and export and between human and artificial sensing, I argue, sheds ethnographic light on the current state of Danish Welfare. Here, I build on Kaj Ove Pedersen's (2011) analysis of the Danish Welfare State and its ongoing transition to rather neoliberal forms of governance, including the increased mobilization of the public and private sector to foster efficiency, privatisation, and international competition. By embodying not only promises of bettering water management practices, but also by constructing a discursive, strategic, and commercial infrastructure for profit maximation and market expansion that is carefully orchestrated by the Danish Government, I show how Digital Water is a model for financing the Danish Welfare State. From this light, approaching Digital Water ethnographically offers a perspective on the current developments of Danish Welfare, including its increasingly competitive and neoliberal trends.

Digital Water generates insights on the potential of ethnography as a collaborative, interventionist, and future-oriented practice in trans-disciplinary collaborations.

The experimental workshop on 'Human and Artificial Intelligence in Future Water Systems' that I facilitated in collaboration with my SWIft colleagues and business stakeholders within the Danish water sector had a twofold function. Firstly, it allowed me to further explore how digital water data and the practices of water utility employees are related by means of mutual

validation. If human actors and their ways of sensing and making sense of water increasingly meet machinic ways of sensing and knowing, the question to be asked is perhaps not how water utility operators know and act, as my SWIft colleagues phrased it, but rather how human-machine ensembles do. Workshopping the tensions between human and artificial forms of sensing and knowing through para-site ethnography (Marcus, 2022) and in a reflexive space with my interlocutors, showed the kinds of everyday and hands-on experience that water operators use daily to read, interpret, and act with digital sensor data in practice. This points at how the 'smartness' of digital water systems is situated (Haraway, 1988), along with the kinds of knowledges and forms of expertise through which they are operated by local water utility employees.

In Chapter 7 and the scientific article that it builds upon, I addressed the ways in which I have collaborated with my engineering colleagues in SWIft during my fieldwork. I opened by elaborating on how the disciplinary tensions between my colleagues and me – between computer science and anthropology – have affected my ethnographic sensibility during fieldwork, particularly in Lemvig. I let my colleagues' distinction between the *ideal* and *real* – different orders of reality within computational science – accompany me during my fieldwork. I argued that despite, or perhaps by virtue of, our different epistemic viewpoints, interacting with my SWIft colleagues guided my ethnographic gaze in generative ways. It helped me generate impressions from what I addressed as the ethnographic *actual*: the place where lifeworlds unfold and are experienced in unexpected ways. Attuning to my colleagues' epistemic frames also allowed me to raise new questions and stimulated my curiosity to explore how decision-making processes about water management take place in practice across human and nonhuman actors. These insights, in

turn, helped me gain an epistemic space that contributed to work carried out in data science. Seen in this light, the workshop on 'Human and Artificial Intelligence in Future Water Systems' is a way to channel the tension between anthropology and computer science into a space for trans-disciplinary and collaborative intellectual practice and exploration across academic disciplines and the industry.

Final Thoughts and Future Directions

In this dissertation, Digital Water is articulated as more than a single figure. Moving along its chapters and articles, Digital Water emerges as multiple in how it is imagined, experienced, and has effects on practice across different actors – human and digital. Drawing on Kim Fortun (2003; 2009), I have engaged with Digital Water through an ethnography in/of/as an open system: with an emergent and heterogeneous phenomenon that is (always) not yet and on the verge of becoming (Pink et al., 2016). Seen thus, Digital Water brings otherwise disconnected actors (researchers, water utility operators, public officials) and practices (information exchange, research, sensing, knowing, export, diplomacy, and optimizations of water flows) together and in tension with one another. As it brings diverse practices of commodifying, managing, and understanding water together and in concrescence, I have described Digital Water as an open ecosystem.

By those terms, studying 'Digital Water in Tension', I argue, offers a prism through which to understand, but also to speculate and intervene on Danish water and welfare futures. If, as I have argued, Digital Water is a model not only for the betterment of water flows through digital and technical ingenuity, but also for financing the Danish Welfare State and sustaining its economic future, this dissertation shows that there is an urgent need to reintegrate a

fundamental element of Danish Welfare into the making of Digital Water futures: the social.

Looking forward, this work points at several ways ahead for a critically engaged anthropology of Digital Water. I conclude by sketching three potential future research orientations that draw my attention. One of the central open questions from the workshop on 'Human and Artificial Intelligence in Future Water Systems' regards notions of 'data' articulated by utility employees. According to their position and experience, it seemed that water utility operators, IT specialists, project managers, consultants, and researchers spoke in generic terms of 'data' as if everybody knew what that entails. This opens room for potentially rewarding ethnographic work to nuance how different actors refer to data in different contexts. What would digital water data vernaculars sound like?

With this project, I have also focused quite extensively on portraying how water utility operators' sense of water emerges by way of their ongoing engagement, in perception and practice, with water management systems and infrastructure. This leaves an equally extensive work ahead in exploring not only how digital water sensors experience and learn in their physical surroundings and by their relation to human actors, but also how human and machinic sensing and knowing ensembles experience and generate information with the increasing uptake of generative AI in water management – where the data generation context is digital too.

Lastly, if the future history of water (Ballestero, 2019) is increasingly digital, it seems that Digital Water also moves and reproduces particular perceptions of water management and profit that feed what boyd and Crawford (2012) refer to as the 'new digital divide', namely that which separates 'Big Data rich' and 'Big Data poor' (boyd & Crawford, 2012: 674). In this sense,

datafying water (and capitalizing on scaling this process) might exacerbate divides between ‘water rich’ and ‘water poor’ too. Seen in this light, ethnographic studies of a possible ‘Digital Water divide’ across national boundaries offer an important opportunity for anthropology to take part in constructing socially just Digital Water futures.

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