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Joe Williams, Ross Beveridge, Pierre-Louis Mayaux

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Unconventional Waters: A Critical Understanding of Desalination and Wastewater Reuse

Joe Williams

School of Geography and Planning, Cardiff University, Cardiff, United Kingdom; williamsj168@cardiff.ac.uk

Ross Beveridge

School of Social and Political Sciences, University of Glasgow, Glasgow, United Kingdom; ross.beveridge@glasgow.ac.uk

Pierre-Louis Mayaux

CIRAD, UMR G-EAU, Montpellier, France; pierre-louis.mayaux@cirad.fr

ABSTRACT: The growth of 'unconventional' water resources as a new resource frontier has been much touted over the last two decades and is transforming society's relationship with water in diverse contexts. Desalination and wastewater reuse, in particular, are increasingly framed together as potentially game-changing technologies for water management and (re)distribution and are carried forward by promises to overcome water scarcity and enhance water security. While there are good reasons to critique the conflation of heterogeneous water resources under the single heading of 'unconventional', we argue that the scale and scope of the transition towards desalination and treated wastewater (which often use similar technologies) merit their inclusion in one Special Issue. The papers presented in this issue advance our understanding of the social, political, economic and cultural dimensions of this water transition. The papers are conceptually and empirically diverse, with case studies across the Global North and Global South. They offer an important counterbalance to the dominant techno-triumphalist narratives that typically surround these technologies, providing unconventional perspectives on unconventional water. In this opening paper, we chart the emergence of unconventional water. We then introduce the papers and highlight the cross-cutting themes of the issue: 1) the (de)politicising discourses that frame desalination and wastewater; 2) the political economies of unconventional water; 3) the materiality and politics of these technologies; and 4) their implications for water justice.

KEYWORDS: Unconventional water, desalination, wastewater reuse, water gap

INTRODUCTION

The growth of unconventional water resources as a new resource frontier has been much touted over the last two decades and is transforming society's relationship with water in diverse contexts. Desalination and wastewater reuse, in particular, are routinely presented as potentially game-changing technologies for water management and (re)distribution and are carried forward by promises to overcome water scarcity, enhance water security and, for treated wastewater at least, increase agricultural yields while also improving the receiving environments (Ait-Mouheb et al., 2020; Beveridge et al., 2017; Williams, 2022). As a growing body of critical research shows, however, the transition or 'turn' to unconventional water also raises serious questions around justice and access to water services, political power, financing and corporate interests, environmental impact and sustainability, energy demand, and the distribution of costs associated with these capital-intensive infrastructures.

Unconventional waters are entering the hydrosocial cycle through a myriad of social, political, economic and cultural configurations, from small-scale technologies to mega-infrastructure projects. This is occurring across both the Global North and Global South. Unconventional water technologies are likely to increasingly reshape the practices, politics and political economy of water throughout the 21st century as the climate crisis worsens, water challenges become more entrenched, global economic growth continues, thirsty industries expand, and capital continues to seek out new opportunities for accumulation. Empirical evidence suggests that the creation of 'new water' does not necessarily ease the situation; instead, it may result in, and even compound, inequalities in terms of allocation or access. As such, the contradictions associated with the creation of unconventional water resources will continue to grow.

In this rapidly evolving terrain, this Special Issue brings together new and exciting research on desalination and wastewater reuse in a wide range of empirical contexts to expose the contradictions of, and challenge conventional narratives on, unconventional water.

WHAT IS 'NEW' ABOUT UNCONVENTIONAL WATER?

The term unconventional (or nonconventional) water is certainly not new. It originates from the field of fossil fuels, referring to oil and natural gas that cannot be explored, developed and produced by conventional processes.[1] Interestingly, standard definitions by the fossil industry readily admit that what qualifies as unconventional at any particular time varies. Unconventionality appears as "a complex function of resource characteristics, the available exploration and production technologies, the economic environment, and the scale, frequency and duration of production from the resource" (Schlumberger, 2023). As a consequence, "perceptions of these factors inevitably change over time and often differ among users of the term" (ibid). In the water sector more specifically, the term has been used for decades as an umbrella concept to describe combinations of alternative water resources, usually including the use of desalination and wastewater recycling as a way of alleviating water scarcity in arid and semi-arid regions (Hamdy, 2002; Indelicato et al., 1993); however, it also includes transport of water by tankers and weather modification (Brewster and Buros, 1985), and fossil groundwater (Salem, 1992). Others have adopted a looser definition which includes any water augmentation strategy that either utilises alternative technologies to improve the use of conventional water resources or expands the use of previously untapped unconventional resources (Smakhtin et al., 2001). Allan (1993) uses the concept of "water substitutes" to argue that countries in the Middle East and North Africa used oil capital to substitute for conventional water resources by importing food (Allan later developed this idea into the concept of *virtual water*). Although historically it was predominantly invoked as a solution for the Mediterranean and Middle East, in the 1980s unconventional water also became a focus of the international community as a potential way of addressing water challenges for development in the Global South (UN Department of Technical Cooperation for Development, 1985).

In recent years, there has been a significant renewal of interest among academia, business and governing actors in the potential of unconventional water resources to mitigate global and regional water crises in the 21st century (Karimidastenaei et al., 2022; Qadir et al., 2022). The European Commission's (2022) proposed new urban wastewater directive, for example, overtly targets an increase in the reuse of treated wastewater without being explicit about the uses to which it should be put. The United Nations has created a taskforce with the aim of developing a, "coordinated initiative and global project" to foster international cooperation on this issue and, "to build and share a global vision to harness the potential of unconventional water resources and technologies" (UNU-INWEH, 2017). Under the heading of 'unconventional water', sources being considered by the UN are as diverse as the desalination of

[1] At present, the term 'unconventional' is used in reference to oil and gas resources whose porosity, permeability, fluid trapping mechanism, or other characteristics differ from conventional sandstone and carbonate reservoirs.

seawater and brackish water, the treatment of grey- and wastewater and agricultural runoff, the transportation of icebergs and water by shipping container, the micro-scale capture of rainwater and dew, and the harvesting of atmospheric water through cloud-seeding and fog collection (Qadir et al., 2022). Much of the debate in this area reproduces the idea of a 'water gap' between growing demand for water across much of the world in the context of static, or even reducing supply, as well as a gap between Global North and Global South in terms of capacities to redress balance between supply and demand (UN-Water, 2020). The water gap concept is also shaping popular imaginaries of water; it appears, for example as the framing idea behind a recent edition of *National Geographic* (2023). Conventional water is seen as insufficient for meeting human demands and as increasingly under threat from over-extraction, pollution and climate change. Unconventional water resources are thus presented as a way of closing the gap, maintaining a productivist and growth-oriented model of water management, and achieving the Sustainable Development Goal of delivering safe and reliable water access to all.

One could be forgiven for wondering why such a diverse list of water sources should be considered under the same heading. For one thing, these sources of water are extremely heterogeneous in terms of their material, geographical, technological, scalar, social and economic characteristics; for another, they are diverse in terms of their actual utilisation, potential and scalability. Some unconventional waters are already multibillion dollar industries, as in the case of desalination and wastewater; some are already widely used, as in the case of micro-scale rainwater harvesting; while others are still some way from being demonstrably feasible. Cloud-seeding and weather modification, for example, have been extensively studied in multi-year projects at a number of locations, and while there is evidence that rainfall can be artificially increased at certain times and in certain places, it is a long way from being considered a reliable and safe source of additional water (Malik et al., 2018; Ryan and King, 1997). Similarly, iceberg towing, although theoretically feasible, has been in the realm of scientific fantasy since the early 20th century (see Lewis, 2015).

While there is thus good reason for distinguishing conventional and unconventional water, one must remember that this distinction is always, at least in part, discursively constructed and materially fragile. 'Conventional' drinking water, for example, becomes 'unconventional' when it is reused as wastewater, before being made 'conventional' again when discharged into the receiving environments and mixed with other water. Similarly, many users, including urban households, are much less interested in this distinction than are water experts and scientists, as water's availability is more important to them than its specific origin or mode of production. Farmers, for their part, assess unconventional water resources relative to the availability of a range of 'conventional' alternatives and/or use them in conjunction with other water supplies. Unconventional waters thus cannot be neatly separated from conventional waters and they are very much connected to the social relations, power dynamics, economics, infrastructures and materialities of conventional waters. As such, the changing ways in which the boundary is drawn between the two categories of resource needs to be interrogated, paying particular attention to the politics of this distinction.

On the one hand, conflating water resources that might be considered speculative (in the case of cloud-seeding) or may invoke consumer reluctance (in the case of wastewater – see Duong and Saphores, 2015) with sources such as seawater desalination that are more associated with high technology and innovation, could be a discursive political tactic to legitimise the former. Unconventional waters are presented as new, exciting and high tech, in comparison to boring and overburdened conventional water. It therefore makes for an attractive heading in the promotion of particular technologies, industries and skills. On the other hand, labelling water resources as new or unconventional can hide or obscure existing, and often disputed, claims to that water. This is true in particular for wastewater, which is often (although not always) already used by humans and environmental flows. In this case, the framing of this resource as unconventional conveys the image of a clean break with the past, which renders invisible the reallocations that take place when official projects are implemented (from informal and free uses to formalised and chargeable ones). However, this is also true for seawater – and even for brackish

groundwater – that usually plays a variety of valued roles for humans, non-humans and ecosystems prior to any infrastructure project.

With these caveats in mind, we nevertheless feel that there is traction and merit in discussing desalination and treated wastewater reuse together for the following reasons. First, they are the two most rapidly expanding sources of 'new' or unconventional water today. According to the Global Water Intelligence database, cumulative online desalination capacity went from virtually zero in 1966 to around 21 million cubic metres per day (m^3/day) in 2000, to over 91 million m^3/day in 2021. By then, 21,055 desalination plants were operational (GWI, 2022). Meanwhile, direct use of treated wastewater has also increased significantly worldwide, although, overwhelmingly, water reuse continues to concern untreated wastewater and/or treated wastewater that is released into existing water bodies. Thebo et al. (2017) thus calculated that around 35.9 million hectares (ha) of irrigated croplands have high levels of dependence on urban wastewater flows and that 82% of this cropland is located in catchments with low levels of wastewater treatment. Global cumulative installed capacity in municipal treated wastewater reuse rose slowly up until the mid-2000s, however, increasing from about 57 million m^3/day in 1991 to 67 million m^3/day in 2005. It then accelerated sharply to 169.1 million m^3/day in 2020 (IDA, 2022: 6-14). The area covered by some planned reuse of treated wastewater is estimated to be around 1.35 million ha, and is mainly in the Middle East, North Africa and Western Europe (Drechsel et al., 2022). Underlying this progression are increasingly massive investments from both public and private sources, with large projects typically costing hundreds of millions or even billions of US dollars. Both desalination and treated wastewater reuse are thus at the centre of extraordinary metabolic transformations of the hydrosocial cycle in diverse contexts and at different scales and magnitudes. Both are likely to continue to shape water governance and politics in many places throughout the 21st century.

The second reason to discuss desalination and treated wastewater together is that, although most critical research has so far considered them separately, industry and governing actors are increasingly considering them together under the heading of unconventional water. Critical social research should do the same if we are to engage with, and critique, this emerging narrative.

Third, although wastewater reuse is materially and infrastructurally much more heterogeneous that desalination, both processes often use similar membrane technologies, which are often delivered by the same global water companies. Unlike dams, both are also usually located in coastal or low-lying peri-urban areas and thus face specific constraints in terms of access to land and energy costs.

UNCONVENTIONAL PERSPECTIVES ON UNCONVENTIONAL WATER

Given the emergence and solidification of the concept of unconventional waters in the global discourse and the potentially transformative character of some of the water sources under this heading – particularly desalination and wastewater – there is a need to challenge conventional understandings and framings. The current debate on unconventional water tends to be characterised by techno-triumphalism, which is the belief that complex challenges such as water stress can be solved by technology without the need to address social and political factors. A recent paper published in a high-impact environment journal, for example, is accompanied by a graphical abstract showing a systems diagram where a depiction of the earth as a frowning-face emoji turns into a smiling-face earth emoji through the application of new water resources. This graphical abstract has the slogan "Unconventional water resources: A golden opportunity toward mitigating the water supply-demand gap" (Karimidastenaei et al., 2022). Techno-triumphalist perspectives on unconventional water, as shown by Feng (this Issue), are also strongly linked to ecological modernism, where technological innovation is seen as the primary route to environmental sustainability. While the potential tradeoffs of new water technologies have also come under scrutiny (Yazdandoost et al., 2021), alternative perspectives are needed to balance the debate, to problematise technocratic framings, and to foreground issues of politics and justice.

The papers in this Special Issue reframe the debate in a number of important ways. Below, we highlight some of the cross-cutting themes of the issue.

(De)politicising discourses

Depoliticisation is the means through which choice and controversy (politics) become obligation and consensus. The articles in this volume provide crucial insights on the discursive struggles that are at the heart of the politics of unconventional water; they show that the dynamics of depoliticisation are closely bound to those of politicisation. Indeed, a number of papers make the case for a politicisation of unconventional waters on democratic grounds and via the means of an assertion of contingency and diversity in decision-making, as well as the inclusion of multiple ways of knowing and governing water. Depoliticisation is not, of course, a condition that is confined to unconventional waters. It is arguably both characteristic of politics in the age of neoliberal globalisation from the 1990s onwards (see, for example, Mouffe, 2005; Crouch, 2004); it is also, paradoxically, a strategy and outcome that is fundamental to politics per se (Schattschneider, 1975). If the former revolves more specifically around the neoliberal disenchantment of politics by economics (Davies, 2014), and the latter captures multiple moves to embed and naturalise one view of the world at the expense of others (Hay, 2007), the papers in this Special Issue provide rich illustrations of both. It is abundantly clear that unconventional waters are reliant on diverse forms of depoliticisation; indeed, at least at the current conjuncture, depoliticisation of forms of treated wastewater or desalination is a fundamental part of the move to make them (politically) conventional, even when there is a celebration of their technological novelty and daring.

In its clearest terms, the depoliticisation of unconventional water is a strategic means of removing controversy as well as alternatives. O'Neill and Boyer's paper on Arizona (this Issue) shows how the over-optimism and overreach of techno-fix solutions like desalination marginalise alternative approaches to adapting water infrastructure to climate-changed futures. Other 'tools in the box' such as water recycling and rainwater harvesting are largely sidelined in planning. This is a testament to the potency of the discourse coalition – with its embedded economic interests – that is typical of desalination projects around the world. This chimes with the work of Swyngedouw and Williams (2016) who have argued that desalination is presented in win – win terms, the technological state of the art providing environmental sustainability and economic productivity by making water abundant in places where it is under stress, such as Spain.

O'Neill and Boyer's contribution is also important, however, in showing the institutional and material dimensions of the depoliticisation of desalination. It stresses that desalination entails large financial and political outgoings, which are hard to push back against once in place, with supporters reluctant to concede ground given their investments and opponents concerned about the costs, politically and financially of giving up on them (O'Neill and Boyer, this Issue). Depoliticisation is not merely a discursive process; it is also an institutional process that entails the making of laws and organisations, and a material process whereby, for example, sunk costs and the material presence of infrastructure projects can build path dependencies that become self-reinforcing and thus eliminate alternatives. Of course, unconventional waters may also initially rely on the politicisation of existing water practices and institutions, on the assertion of choice and alternatives, and on being disruptive in their recourse to expertise and its promise of progress and order. Hence depoliticisation is on a continuum with politicisation, closely interconnected with its antonym (Beveridge and Naumann, 2014).

The discursive realm is crucial to the way in which technologies of desalination and wastewater reuse do or do not become situated. Patel's detailed discourse analysis of the public statements and official deliberations on the Huntington Beach (California, USA) desalination facility reveals the key themes that arise in debates; these are the themes that also resonate across this Special Issue. 'Storylines' were deployed by proponents of, and opponents to, the politicisation and depoliticisation of desalination. They

shaped the discursive territory, centring on environmental damage, water supply, cost considerations, climate change, privatisation, the human right to water, and stakeholder representation (Patel, this Issue). The facility was ultimately denied, even if the regulatory agencies involved displayed a cynicism towards the concerns of stakeholders. This study provides an important contribution in the way that it demonstrates that depoliticisation and politicisation do not always function as coordinated strategies; it shows that, rather, they are bound up with diverse agencies and agendas, relying on, and indeed produce, ambiguity. Eid-Sabbagh's analysis (this Issue) of the sociospatial politics of wastewater reuse in Lebanon, while not adopting an analytical focus on (de)politicisation, also displays the rich and complex politics of conflict avoidance, contestation, and the shifts between order and disruption.

Paradoxically, then, there is a politics of depoliticisation in relation to unconventional water; the assertion of particular interests and visions, at times very localised, at others feeding into a broader technocratic and commoditised framing of water. Crisis, whether economic, social or climate, is frequently crucial to discourses of depoliticisation. As is shown by Velasquez and Wachtendorf (this Issue) in the case of the San Andrés Island in the Caribbean, crisis is discursively constructed to suit particular interests and courses of action. In this case, a crisis of water scarcity was constructed in relation to the apparent abundance of water in the ocean that was waiting to be tapped into through desalination. The authors show that the crisis was not one of absolute scarcity, but rather that it was shaped by a range of inadequacies that fed into water injustices. Desalination, with its promise of abundance, does not translate into abundance for all; instead, it feeds into, and extends, inequalities due to socio-economic factors (including high costs) and infrastructural factors (because supply is prioritised for affluent, tourist-dominated areas). A slightly different picture emerges in Chile, where government-led attempts to implement community-level desalinisation programmes provide something of a counterbalance to top-down depoliticising implementation of this technology. Torres et al.'s case study of community desalination projects (this Issue) shows that, when desalination is positioned at the local level it becomes subject to different claims, an object of politicisation, including as a counterpoint to market forces.

What can be done to counter the seeming weight of depoliticising discourses in relation to unconventional waters? Mayaux and Ennabih's article (this Issue) on wastewater reuse for irrigation in Morocco and Tunisia argues for a re-politicisation of wastewater reuse. By this, the authors seek a discursive space that is characterised by choice and by a diversity of differences rather than oppositions, a space in which deliberation might then be attuned to tradeoffs and compromises. The hold of depoliticising discourses is also likely to vary according to the end uses of water. Wastewater reuse for potable water and household use appears less amenable to discursive depoliticisation, the resistance of users being higher than it is in relation to desalination, as March et al. (this Issue) show in their study of Barcelona.

Like Mayaux and Ennabih, the contributions of Palrecha and Sheth (this Issue) and Wessels (this Issue) call for a politicisation of wastewater reuse, this time through an assertion of the political nature of water itself and its release from expert and technocratic control. The starting point for the analysis as well as the governance of unconventional waters must be, Wessels claims, the embrace of the plurality of understandings it generates. The analysis of biophysical and sociopolitical processes of water in Dar es Salaam as being interwoven and complementary serves to open the discursive space to the knowledge of the urban farmers who are engaged in wastewater use on a day-to-day basis. It lays bare the potential and limits of wastewater reuse and may open possibilities for its more democratic and equitable governance.

There are also powerful imaginaries at play that work to shape the political field of unconventional waters, including what is made to seem (im)possible and (dis)advantageous (Takman et al., 2023). We might understand these to be discursive storyboards to which actors are responding and which they are using strategically, seeking to propagate, and – as with case of the farmers' knowledge systems in Dar es Salaam (Wessels, this Issue) – sometimes undermining. Takman et al. (2023), for example, identify three imaginaries of unconventional water. The 'modernisation imaginary' is a narrative that wastewater reuse

is an economic necessity; this is strongly apparent in O'Neill and Boyer's article on Arizona (this Issue). The 'decentralised democratic community imaginary', on the other hand, (Takman et al., 2023: 215), claims to increase water independence and local power; this imaginary resonates strongly with Torres et al., on Chile (this Issue). The 'sustainability imaginary' is often used to position treated wastewater, and to a lesser extent desalination, as the 'sustainable' alternatives to large-scale projects (ibid). This imaginary, however, appears not to hold across the papers. This is perhaps most clear in Patel's detailed analysis of the storylines around the proposed desalination plant at Huntington Beach in California. In that case, sustainability is better understood as a contested discursive space where both opponents and proponents of desalination claim ecological benefits. A focus on discourses of (de)politicisation reveals crucial contests in the struggles over the future of unconventional waters.

Unconventional political economies?

Unconventional waters are shaped by powerful political-economic forces while themselves producing a new political economy with its own specificities. As a political-economic outcome, unconventional waters do not simply represent new or alternative resource futures; rather, as March et al. (this Issue) argue, they sit at an economic frontier that offers new forms of accumulation and economic growth. The creation of 'new' water resources is seen by many actors – states, governments, corporations and financial investors – as an economic opportunity to both make money in the water sector and drive economic growth in other sectors. There is thus a distinct political economy of unconventional water (Fragkou and Budds, 2019). In places such as in the Arabian Peninsula and North Africa, unconventional water has been enrolled into political-economic structures in ways that reinforce state-led forms of economic development (Al-Aghbari, 2021). Saudi Arabia is in the process of privatising many of its desalination plants and has adopted a model of independent water and power producers for infrastructure delivery, wastewater and desalination. These are still intimately connected with state-led development and with fostering state legitimacy through growth-oriented policies. These processes are particularly well established in Israel for both desalination and treated wastewater. There is extensive literature that elaborates on how political and business leaders in Israel see the unconventional water sector as a way of securing growth in key economic sectors such as agriculture as well as demonstrating technological leadership, solidifying a dominant technological and economic position in the region (which has changed the geopolitics between Israel, Palestine and Jordan), and exporting Israeli technology and corporations globally (see Feitelson, 2013; Katz, 2021).

The transition to unconventional waters has also been accompanied by processes of decentralisation, privatisation, commercialisation and financialisation of water services. In this Issue, these processes have been highlighted in a number of accounts; they include that of: an international water company's disproportionate role in shaping water management in San Andrés (Valásquez and Wachtendorf); the attempted development of the Huntington Beach desalination facility in California that was led by an investment company (Patel); the role of private actors in wastewater treatment in Barcelona (March et al.); and the economic and financial imbalances that have shaped the (mis)use of wastewater in Lebanon, particularly the role of neoliberal international donors in setting the parameters of water infrastructure development in the context of severe economic crisis (Eid-Sabbagh). However, even in contexts where unconventional water is driving the growing role of private and financial actors in water governance, the state still plays an important role in enabling and shaping this transition (O'Neill ad Boyer, this Issue).

Many contributors to this Special Issue, in turn, describe the specific political economy that is fashioned by unconventional waters. Some of its features appear to be common to both water reuse and desalination, but distinctions remain between these forms of unconventional water. Within the first category, the structurally high operating costs of both technologies tend to generate a fraught political economy. This challenge is largely downplayed by dominant, technocratic framings that tend to focus on investments and fixed costs (and how those are ultimately 'worth it') to the detriment of more mundane, politically less-attractive issues such as operation, maintenance and monitoring. High operating costs are

related, in particular, to high energy consumption, both to power production processes, especially in the case of desalination (i.e. reverse osmosis) and to pump water upstream, as both desalination plants and wastewater treatment plants are located in low-lying areas. High costs may also be related to high land prices in metropolitan areas. This encourages the adoption of more intensive, denser and more expansive technologies such as (in the case of Beirut) sophisticated processes of biofiltration in wastewater treatment plants. Finally, in the case of treated wastewater, it is also due to high monitoring costs, as wastewater carries particular health risks that require more stringent regulations, and more thorough enforcement, than is the case for conventional water. Who pays what, when and how is thus a perennially tormenting issue for many unconventional water stakeholders.

In the case of Chome in southern Chile, for example, the money collected from water bills does not cover even half the salary of the plant's only employee (Torres et al., this Issue). Unsurprisingly, the community feels strongly that the municipality should finance the maintenance costs of the desalination plants, although this is far from a done deal. In Tunisia, likewise, the Regional Department for Agricultural Development (CRDA) has been pushing the Water Users Association to increase the price of reused wastewater so as to alleviate its own financial burden, but to little avail. Until 2017, water prices remained at 20 millimes per cubic metre (less than one US cent) before being increased to 45 millimes in 2019. According to CRDA's calculations, however, the recovery of energy costs alone would require a price of 255 millimes (around 8 US cents). Similarly, Eid-Sabbagh (this Issue) shows how, in Lebanon, poor governance, high public debt and unstable relationships with international donors have led to much of the infrastructural capacity for treated wastewater remaining idle. There are also many examples of large desalination plants that, despite large fixed capital costs, have not been cost-effective to operate; these include Beckton in the UK, Santa Barbara in California, Tampa Bay in Florida, and most of the large plants in Australia that were constructed at the end of the Millennium Drought.

Water reuse and desalination also produce political economies with their own distinct characteristics. Mayaux and Ennabih (this Issue) highlight the specificities of the (cultural) political economy of treated wastewater reuse for irrigation. They particularly highlight three structural, political-economic contradictions: between the state's preference for the largest possible schemes and the lack of interest of (many) peri-urban farmers who would rather urbanise their land and/or practise low-intensity farming alongside other occupations; between high operational costs and the poor smallholders who are typically targeted; and between the pockets of stringent state monitoring thus created and the surrounding sea of laisser-faire. This 'unconventional' political economy creates lasting tensions and difficult negotiations between the different stakeholders.

Another notable difference between the two technologies lies in the differential opportunities for accumulation that they offer. Desalination is, on average, a more profitable venture than water reuse. It can produce stable financial profits over the several decades that a facility stays online (Pryke and Allen, 2019). One of the reasons for the greater security of its business model is that desalinated water it is mostly intended for drinking water purposes and for some industrial uses, and that urban consumers' willingness to pay for drinking water is high. Thus, with its large size and operational life of anywhere from 30 to 50 years, the Poseidon facility would have secured not only water but reliable revenues from local ratepayers for the company's globally dispersed shareholders. Treated wastewater, by contrast, is more often used by farmers whose capacity to pay is much lower. Alternative funding mechanisms meanwhile remain uncertain, as urban consumers, for example, have a limited willingness to pay for sanitation; this willingness is possibly even lower if their bills are used to fund wastewater reuse for agriculture. March et al. (this Issue), in their study of Barcelona, point out that business interest in wastewater reuse remains limited despite its promotion by the city government and the EU. As the authors note, the advance of wastewater reuse technology is unsure and its success will depend on the extent to which major economic players invest in its development financially and politically. Thus, while attracting private operators into the water reuse business has been on the agenda since its inception, it has failed to gain traction in most countries, especially in the Global South.

As we discuss below, there is huge variation among the materialities of wastewater treatment and desalination (and indeed among different types of each of these forms of alternative water). As a result, the ways in which they are enrolled in political-economic processes varies by technology as well as context. Nevertheless, as all the contributions to this issue demonstrate in different ways, the transition to unconventional water is always shaped by, and in turn shapes, political-economic structures and processes.

Materiality and politics

Compared to conventional water resources, especially surface water, unconventional waters have a quite distinct materiality. This materiality translates into a somewhat distinct politics. In this respect, desalination and water reuse have both important commonalities and noticeable differences. Important commonalities include their path-shaping properties and the downscaling of politics that they tend to instigate.

The creation of path dependencies is a commonplace of any water infrastructure, especially when it is large-scale (Ingram and Fraser, 2006; O'Neill and Boyer, this Issue). In this regard, unconventional waters are thoroughly conventional; their high fixed costs, economies of scale, network effects and learning effects imply that, once set up, any future dismantling and the pursuit of alternative paths may become more and more unlikely (McEvoy and Wilder, 2012). This is especially the case since large-scale projects tend to be preferred, as unconventional waters are generally infused with the dominant hydraulic paradigm that champions centralised, large-scale interventions in the hydrosocial cycle (Saurí and del Moral, 2001). Path dependencies have been much discussed in relation to conventional water resources, however their specific mechanisms have yet to be properly inventoried and analysed in the case of unconventional waters. Most of the reflections, even from the social sciences, tend to be focused on project selection, conception and implementation, and less on their long-term, self-reinforcing political-economic effects. Various contributions to this Special Issue show that large desalination or reuse projects reduce the flexibility of future generations to respond differently. In Arizona, political attention to large-scale desalination has led to the lack of financing of smaller-sized, but potentially more widely applicable, technologies. Likewise, on the island of San Andrés, desalination has made a rain harvesting program that would have involved the construction, pre-cleaning, inspection and maintenance of cisterns appear less necessary, and therefore much less likely (Valásquez and Wachtendorf, this Issue). In California, it was argued that the Poseidon Huntington Beach desalination plant would have locked in high greenhouse gas emissions and energy consumption and would therefore have constituted a case of 'maladaptation' to climate change; this weighed heavily in the final rejection of the project (Patel, this Issue). This last case shows that when path dependencies are socially recognised, they can fuel the politicisation of a project before it is adopted, precisely because of the awareness that this moment of choice could be the last significant one for a long time.

A more distinct property of unconventional waters is the downscaling of politics that they instigate, usually as the result of a deliberate strategy on the part of their promoters. Located in (peri-)urban areas, with less distance to users and greater autonomy over resource access, the introduction of unconventional water infrastructure is often part of a strategy to avoid dependence on the constraints, vulnerabilities and politics of the broader watershed (Ennabih and Mayaux, 2020; Morgan, 2020). In that sense, they instantiate a certain form of technopolitics, that is, the active utilisation of technological development to further a political goal (Hecht, 1998; Mitchell, 2002). In Arizona, for example, the treatment of brackish groundwater and agricultural runoff (the Yuma project) would allow the state of Arizona to reduce its dependence on Lake Mead, and the associated contentious politics of the Colorado River basin, and in California the Poseidon project was all about fostering a more "locally diverse water portfolio". Meanwhile, the promotion of unconventional waters in Barcelona has been part of a strategy to avoid dependence on large inter-basin transfers such as that from the Rhône (Gorostiza et al., 2018). This general rule has exceptions, however, such as in the case of a small island like San Andrés where

desalination rather serves as a unifying (although deeply uneven and unequal) strategy for the whole territory.

In general, the downscaling of politics implies not so much a democratisation of the decision-making process as a restructuring of power constellations between dominant actors. Barcelona provides a telling example of this dynamic, where the reusing of greywater is partly the vehicle of an 'elite club' strategy whereby affluent municipalities seek to sever themselves from large networks with all their associated vulnerabilities (whether in terms of supply security or risks of price increases) and mechanisms of solidarity. Sant Cugat del Vallès, one of the main promotors of this technology, is one of the most affluent municipalities in the Metropolitan Area of Barcelona.

Alongside these commonalities, however, desalination and water reuse also have their own material and politically relevant specificities. Noticeable differences relate to water quality issues and to the dynamics of water reallocation that they may imply. While the quality of desalinated water is usually perceived as being fairly reliable and low risk, wastewater reuse is plagued with concerns over water quality and with an associated politics of disillusion, blame-shifting and user stigmatisation. This is the case, of course, when untreated wastewater is used for agriculture. In this case, lack of proper treatment means perennial informality with all its associated precarities, while the very real interdependence between urban and rural areas tends to be obscured by symbolic dichotomies that contrast the properly developed 'clean' city with underdeveloped 'dirty' rural practices. In Dar es Salaam, farmers who use wastewater informally are routinely stigmatised as being the authors of unsafe and dirty practices. This largely erases the role of urban users in creating wastewater in the first place, and obscures public authorities' long-standing failure to treat that wastewater; it also overlooks the dependence of many city residents on local food production and the complexities of farmers' water uses, for whom wastewater is only one water source among others. Likewise, in Rajkot, India, the informal use of wastewater (mixed with river water) downstream is not backed by any formal rule. Authorities' relative leniency is best described by what the political scientist Alisha Holland calls "forbearance", that is, "intentional and revocable government leniency toward violations of the law" (Holland, 2017: 14). It confers "special benefits only to specific people for a particular time", as Alka Palrecha and Aashini Sheth aptly describe.

Quality issues also plague treatment plants and their effluents. In Lebanon, for example, out of the 17 larger wastewater treatment plants (WWTPs) that, in 2020, were being managed by the national Council for Development and Reconstruction (CDR), only 6 were considered operational. As for the many smaller-scale, municipally managed WWTPs, the US Agency for International Development could only observe that, "the use of treated wastewater for irrigation is at present impossible, due to the poor quality of the effluent". In Tunisia, as Mayaux and Ennabih recount, an official from the Ministry of Agriculture admitted that wastewater treatment throughout the country was plagued by "technical problems, breakdowns, problems with pumps and problems of water quality".

Participation and environmental justice

The various contributions to this Special Issue largely corroborate the view that unconventional waters are no more inclusive, participatory, or fair than their large-scale, conventional counterparts. Indeed, the turn to unconventional waters can further entrench inequalities and injustices by deepening uneven Global North – Global South relations. Valásquez and Wachtendorf (this Issue), for example, show how the use of desalination has increased the financial and technological dependence of San Andrés on an international private water company, and Eid-Sabbagh argues that wastewater treatment has entrenched uneven neocolonial relations between Lebanon and international donors. This is an aspect of unconventional water that, with some notable exceptions (Fragkou, 2018; McEvoy and Wilder, 2012), has largely been overlooked in the literature and is in urgent need of critical attention.

As a general rule, the contributions show that decision-making processes around unconventional waters take place in technocratic arenas to which access is highly restricted (Campero et al., 2021).

Valásquez and Wachtendorf (this Issue), for example, show how in San Andrés, despite strong support for desalination, disadvantaged groups (the Razales) felt that they had not been properly consulted and that their interests had been sidelined by those of the tourism industry in a consultation process that was marked by the promotion of technical expertise. Being framed as a supply augmentation measure, 'new waters' appear to be largely devoid of any redistributive dimension. Even in contexts where public authorities have invested in extensive consultative processes in order to overcome resistance and foster consensus, the contributions show that the effective participation of outsiders remained thoroughly limited. California shows both an example and a counter-example of this. In the case of the two Poseidon desalination projects in California (in Carlsbad and Huntington Beach), multiple stakeholder groups, including government officials, residents, environmental organisations, labour groups and tribal representatives, extensively debated the facilities along a variety of themes such as environmental damage, cost considerations, climate change and the human right to water. Arguments by local environmental groups (such as Coastkeeper, Surfrider and the Sierra Club), residents, and tribal representatives around themes of environmental justice were influential, but they were ultimately unsuccessful in halting the Carlsbad facility. Seven years later, however, they were successfully mobilised to contribute to the cancelling of the Huntington Beach project; they were helped in this by a stringent permitting process and by the adoption by regulatory agencies of environmental justice policies (Patel, this Issue). Another exception to the rule might be the case of community desalination in southern Chile. There, the installation of desalination units was supported by participatory workshops within each community that served to provide detailed information about the plants and to undertake consultation and collect information about their social perception of the drinking water produced by the plants (Torres et al., this Issue)

In part, exclusionary decision-making processes are justified – and thus facilitated – by the prevailing depoliticising discourse around unconventional waters. This discourse portrays them as a technical local fix for water scarcity that will provide a 'new' water supply for urban expansion and agricultural development (van der Hoek et al., 2016). Feng et al. (this Issue) show how a wastewater treatment scheme for Chongming Eco-Island in China, which was framed by authorities in eco-modernist and depoliticising terms, was strongly contested by local residents because it was seen as a top-down project that would lead to the displacement of their rural livelihoods.

The turn to unconventional water resources therefore risks deepening forms of procedural and recognition injustice. When potential participants are not considered as legitimate stakeholders, for example, including them in a consultation process becomes inconceivable. In Dar es Salaam, having farmers actively partake in the planning of urban land and water would require recognising agriculture as part of the city's future, something that is highly contested. Likewise, in Rajkot, rural wastewater users are struggling to get recognition of their very existence in the discourse and policies of wastewater and wastewater reuse. Formally acknowledging these uses would be a preliminary step to any future inclusion in a participatory process. These examples illustrate how wastewater, especially in the more water-stressed areas of the Global South, is already being widely used by humans; this is much less directly the case for ocean water or even for brackish groundwater, which tends to be discarded even for agricultural uses. Wastewater reuse, therefore, can hardly be seen as having uncapped and untapped potential that is yet to be fully embraced. Many small-scale farmers, in particular, rely on urban return flows for irrigation, although these practices are seldom officially acknowledged (Drechsel et al., 2010). As a consequence, officially planned treated wastewater reuse projects are often a site of fierce recriminations from former users who claim some forms of historically derived rights over wastewater; this is illustrated by the case of Tizinit in Morocco (Mayaux and Ennabih, this Issue).

The fact that access to decision-making arenas is severely restricted has the effect of rendering invisible some issues that are important to marginalised stakeholders. This invisibilising effect is evident in the case of California where, unusually, many marginalised stakeholders were able to voice their concerns, albeit with limited influence in the end. Their concerns included not only cost considerations

and environmental damage, which are lines of criticism that are often anticipated by project promoters; they were also concerned about the human right to water, issues of water privatisation and (lack of) stakeholder representation, which are types of criticism that were much less anticipated and which, one might assume, could well be expressed elsewhere if a decision-making process was more inclusive.

CONCLUSION

This Special Issue provides glimpses of the global context of unconventional waters. These insights have reinforced some existing concerns in the literature; they lay bare the strength of corporate interests in the advancement of desalination and unconventional waters, and the exclusion of local stakeholders and knowledges. New insights, however, have been plentiful. The richness and diversity of the case studies has underscored the ambiguity surrounding unconventional waters and the complex intertwining of the social, technological and environmental that is generative of uncertainty and contestation. Alongside calls for a politicisation of unconventional water, the contingency of many projects detailed here has also laid bare the flickering possibility for more democratic and just water futures. Diverse forms of water knowledge, discursive space for their articulation, and the political processes that seek to embrace them can be seen as fundamental to democratic water governance in general; however, the techno-triumphalism that is backed by the alignment of major economic and political interests around unconventional waters make these fundamentals all the more necessary. Alternative narratives and counter-storylines that detail, for example, the local political economy of unconventional water are essential, as is the facilitating of the means by which they can become heard in the face of daunting challenges.

How might future research engage with unconventional waters? Despite their diversity, the papers presented here share a concern about the ways in which unconventional waters are being expanded. They provide many cues as to what shape the research agenda should take, such as (de)politicisation or knowledge production (and exclusion). Most of the articles here are focused on case studies. It is clear that comparative work can be a crucial means for developing a broader sense of general/global and particular/local dynamics and that it can help importantly in the deepening of knowledge around the geographies of unconventional waters. Coming to terms with political-economic power across geographic scales and spaces feels urgent. It could entail a concern for the alliances and alignments between major corporate actors, international institutions, and national/local politics. Alongside this, there is a need for more research on key corporate actors (such as Veolia or the Agbar Group) in terms of how they define their interests and strategies and how this varies globally. Multiple advancing crises (including of climate and economy) will shape the path of unconventional waters and it will be crucial for research to detail the ways in which crisis is mobilised to expand desalination or wastewater reuse, as well as to report on those contexts where they deepen crisis.

While distinctions remain between desalination and wastewater reuse, researching them together as unconventional waters has not merely revealed similarities; it has also opened up the potential for cross-fertilisation in debates. This is no simple academic ploy, as the water industry itself is already considering desalination and wastewater reuse in the same category. New formations of capital, knowledge and technology are already taking shape and corporate and political strategies are being realigned, with likely far-reaching ramifications. This Special Issue thus hopes to open up new ground for academic dialogue on this key frontier in water governance.

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