







Analysing water provision in the critical interface of formal and informal urban water regimes

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ABSTRACT

Science and technology studies and urban political ecology have made important contributions to the understanding of water provision in the Global South. In this article we develop insights from these fields with the aim to understand the blurring boundaries of urban water regimes and their power relations mediated by actors, institutions and technology. Furthermore, we explore how urban water regimes can form a critical interface which is a form of institutional–actor space where formal and informal water regimes encounter each other through conflict and cooperation.

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Introduction

Since the last couple of centuries, cities have built their water infrastructures based on the principles of a centralized piped network (Goubert, 1989; Melosi, 2000). Importantly, in the Global South, this principle has not yet succeeded in ensuring water access to the urban poor, a large section of which still remains disconnected from water services that are critical for human well-being (Bakker, 2010; Page, 2005). The quality and quantity of the water service available can be inadequate, dubious and sporadic. Given current shortcomings of municipal water provision systems, a variety of different actors are playing increasingly more influential roles in shaping water access to the poor through modes of water provision that are situated outside the municipal boundaries of the piped network (Karpouzoglou & Vij, 2017; Venkatchalam, 2015; Vij et al., 2019; William et al., 2018).

This becomes clearer at the local level where water access is achieved through a variety of practices and technologies. For example, an increasing number of small-scale water vendors have been able to keep the water flowing in the absence of municipal water provision (Kooy, 2014). However, because these services and actors are often not directly

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controlled by municipalities or supported by state regulation, they can be ignored in policy and decision-making. It has been argued in the literature that it is partly the weak understanding of the informality shaping water provision that has made it particularly difficult to develop socially inclusive policies for water service delivery in urbanizing cities (Ranganathan, 2014). Therefore, we see increasingly a tension played out between efforts, on the one hand, to increase formalization of water services, often through greater municipal control and state regulation, and, on the other, a lack of recognition of the continued importance of the workings of informality when it comes to water supply and provision (McDonald & Swyngedouw, 2019).

In this article we use the term ‘formal’ to describe water supply that is delivered by the state and the term ‘informal’ to describe water provision that is provided by actors that are not part of the state. Furthermore, we adopt a critical approach in using the terms ‘formal’ and ‘informal’ to explain the tensions and overlaps across state supported water supply on the one hand and non-state alternatives.

Scholars and policy experts have for decades stressed that informal water services are important to study, alongside the formal providers, in order to develop a more comprehensive account of the local realities of water access in urbanizing contexts (Budds & McGranahan, 2003; Collignon & Vézina, 2000). It is also important to recognize that even though the boundaries between different kinds of water services are blurred and often contested in policy and academic debates, there are nevertheless crucial daily interactions that extend beyond the borders of state actors which remain poorly understood.

To develop a better understanding of the blurring boundaries of urban water regimes and their power relations mediated by actors, institutions and technology, we turn to two bodies of literature that have made important advances in recent years: science and technology studies (STS) and urban political ecology (UPE). We purposefully develop insights from the two fields to address the blurring boundaries of water regimes (an STS perspective), exemplifying the heterogeneity of water actors, institutions and technology as well as the power relations (the latter being a UPE perspective). The two perspectives accentuate the heterogeneous infrastructure configurations’ role in shaping how formal and informal water regimes operate and interact. The contribution of this literature review is to show how the regimes vocabulary (when combined with UPE) can be productively applied to contexts where regimes are characterized by heterogeneity and coexistence of formal and informal systems typical of water provisioning in the Global South (Blomkvist & Nilsson, 2017; Furlong, 2014; Lawhon et al., 2018; Narain et al., 2023; van Welie et al., 2018).

Within the STS body of literature, water services are conceptualized as particular kinds of regimes, whereby a regime represents a system where technology has mostly matured and tends to be more widely accepted by actors that are tightly coupled through formal and informal rules (Fuenfschilling & Truffer, 2014; Geels & Kemp, 2007; Smith et al., 2005). The STS literature has productively expanded its focus to include more in-depth analyses of sustainability concerns in urban water services in the Global South (Wieczorek, 2018). We examine this literature for insights into how regimes can be better conceptualized as more blurred systems where there is heterogeneity in terms of how regimes configure with each other to make water supply possible. This resonates with recent urban scholarship bringing attention to water regimes as resembling more

'heterogeneous infrastructure configurations' where different water infrastructures formal/informal, large/small, state/non-state are configured with each other as part of an extended web of infrastructure relations (Lawhon et al., 2018; Smiley, 2020). Drawing from UPE we focus on the contestation that characterizes water regimes in low-income urban areas (Sultana, 2020); the conceptual framing of UPE supports us in deepening the analysis of power in shaping water regimes by emphasizing on such questions as 'who controls, who acts and who has the power?' (Bakker, 2007; Kooy, 2014; Ranganathan, 2014; Swyngedouw, 1999). Lastly, we mobilize the concept of the critical interface, which reflects an amalgamation of STS and UPE insights in such a way that it allows us to explain how formal and informal water regimes interact with each other. Our understanding of a critical interface is inspired by Blomkvist et al. (2020) and Blomkvist and Nilsson (2017), and we define it as the physical and institutional space between formal and informal water regimes, where actors, technologies and institutions encounter each other to provide water services.

The remainder of the article is structured as follows. The next section discusses the STS literature, followed by a discussion of the UPE scholarship. In the following section we describe the nuances of conflict and cooperation between the regimes. In the concluding section we summarize the key insights of this review.

Insights from STS

In STS scholarship, the term 'regime' is used to explain the organization and control over technology by complex constellations of actors and institutions (Geels, 2004; Geels & Schot, 2007; Lawhon & Murphy, 2012). The term first appears in transition studies as part of the multilevel perspective (MLP) that distinguishes three fundamental analytical levels for understanding how technology is organized by societal actors: the technological landscape, regime and niche (Geels, 2004; Rip & Kemp, 1998). Regimes tend to be closely linked to institutional frameworks. Commonly they are understood as the 'grammar' of socio-technical systems, and the degree of their strength depends on the level of structuration and the level of order (cf. Fuenfschilling & Truffer, 2014).

Critical insights from this work have been developed to understand water supply provision as a regime. This literature has thus far been principally concerned with formal water regimes. A formal water regime therefore constitutes political, economic, cultural, institutional and technical components of providing water services as well as actors (Blomkvist & Nilsson, 2017). Furthermore, we may distinguish between formal water regimes where state and municipal actors mobilize large-scale technological networks and capital for delivering water (Hughes, 1993) and formalized approaches that rely less on large grids and increasingly on smaller water grids and technologies. The degree of 'formality' of a regime is closely interlinked with the level of order and structuration, where rules and norms become increasingly accepted and upheld by its constituency (Fuenfschilling & Truffer, 2014). Regardless, formal urban water regimes are typically municipally supported and rely on coded norms, rules and state institutions.

More recent STS literature focusing on the Global South increasingly underscores the importance of more nuanced analyses of regimes even though the role of technology shaping social and material realities of water provision is widely acknowledged within the STS strand of scholarship (Lawhon et al., 2018). Some of the recent studies point, for

instance, towards a Global North bias – particularly in favour of Europe and the Netherlands – and for often assuming that ‘regimes’ are very tightly coupled homogeneous systems (Furlong, 2014). Instead, water regimes in the Global South in reality can be far less aggregated and constituted through formal and informal regimes which are either coexisting or competing (van Welie et al., 2018). For instance, in the low-income settlements of Nairobi, where the large piped systems do not reach, big public bureaucracies such as municipalities have come to rely heavily on local (non-state) actors that help them run smaller water supply configurations such as prepaid water kiosks. Some of these configurations are legitimized through the formal water regime but some are not (Blomkvist et al., 2020; Boakye-Ansah et al., 2019). There is in other words a ‘critical interface’ between the formal and the informal regime and different types of users at the local level. By accepting that there is a critical interface, this strand of the STS literature therefore acknowledges that beyond the large formalized systems we can still identify a crucial physical and institutional space where water service provision is negotiated almost on a daily basis through a combination of formal and informal water regimes (Nilsson & Blomkvist, 2021). Nevertheless, it has been challenging for STS scholarship to properly account for this complexity and for the fact that there are certain types of regimes that cannot fully be conceptualized within the established articulation of regimes.

This has led some scholars to focus on the social interplay between actors inside and outside of a conventional formal water regime, without necessarily naming what is inside and outside, to foreground the multilayered institutional settings of service models beyond the state. Ramos-Mejía et al. (2018) refer to the ‘informal and insecurity’ settings of the Global South where there is significant ambiguity in terms of the role of the state, the market, the community and the household. What this ‘informal and insecurity’ setting means has clear implications for informal water regimes as it is about individuals and communities that have a more diverse portfolio of strategies and livelihoods to face insecurity and uncertainty and operating outside the traditional formal water service model.

Recent work by STS scholars inspired by the conditions of the Global South further stresses the multitudes of social relationships and power hierarchies prevailing in developing countries as fundamentally different from Western Europe where STS approaches were first developed, and these differences need to be mapped and understood, particularly in terms of technology configuration (Hansen et al., 2018). Such contemporary conceptualizations therefore highlight the importance of combining geographical and institutional perspectives alongside considerations of technology in order to understand the context of water regimes. Geographical perspectives in particular are foregrounded to understand the context of a water regime in specific parts of cities and regions (Furlong, 2014; Hodson & Marvin, 2010; Lawhon et al., 2018). Institutional perspectives help examine underpinning ‘rationalities’ that govern actors’ choices and control over technology, norms and regulations and networks (Fuenfschilling & Binz, 2018; Fuenfschilling & Truffer, 2014).

After discussing the way formal and informal regimes operate and the critical interface which binds the two, this review of the STS scholarship also highlights the role of conflict and cooperation (Ramos-Mejía et al., 2018). For this paper, we regard conflict as a situation of confrontation, while cooperation is defined as an act of working together

to accomplish a common goal. Furthermore, following our analysis, conflicts and cooperation are forms of interaction that one can observe when placing particular attention at the critical interface (Vij et al., 2018). Conflicts may emerge, for instance, between an established water regime with a dominant actor, such as a municipal water utility, and an informal water regime where the dominant actor is a private or a community water provider (Blomkvist et al., 2020; van Welie et al., 2019). Normally, these kinds of interactions tend to be downplayed by regime actors as unimportant or peripheral to water services provisioning. However, they are significant as they reflect differences in views about technical performance of the different regimes but also the underlying problems of trust which exist between the formal and informal actors and which can even lead to violent conflicts. On the other hand, when these problems are acknowledged, through special attention on the critical interface, it is possible that different regimes can coexist in a better way despite their different social, technological and institutional characteristics. This kind of cooperation may indicate a mutual benefit among the different regime entities involved. Hence, cooperation among heterogeneous actors can be important in order to align contrasting socio-technical systems (van Welie et al., 2018). On the one hand, cooperation can be driven from formal regime actors, who engage in ambidextrous innovation strategies experimenting with semi-integration of informal providers as part of their regime (Nilsson & Blomkvist, 2021; Nzengya, 2018). Informal regime actors may in their turn develop business models that are driven by cooperation with – and in search of legitimacy from – formal actors. The extent to which important regulations and guidelines, such as for water pricing and quality, are negotiated and taken into account has been shown to be crucial for this relationship (Blomkvist et al., 2020; Boakye-Ansah et al., 2019). Different forms of cooperation are therefore increasingly recognized as important so that the integrity and reliability of the entire water distribution network does not become compromised by the coexistence of parallel and conflicting water regimes. The conclusions we can draw from this body of literature is that a regime can be a helpful analytical construct to understand water provision in the Global South but that its meaning has to be expanded to address the material significance of both formal and informal regimes, as well as the critical interface which binds them together through conflict and cooperation. We will return to the role of the critical interface with empirical illustrations below.

Insights from UPE

UPE originates from political ecology and emphasizes on resource flows through cities, especially the conflicts that result from unequal power relations between powerful and powerless actors (Walker, 2007). In UPE, nature and society are two spheres that are strongly interconnected and physical infrastructure is an important element of urban nature in the analysis. Infrastructure in the Global South is the medium through which ‘socio-natures’ are produced (Swyngedouw, 2007), shaping water access and control. Water flows and access to water are seen as an expression of larger political, economic, social and cultural struggles in society, since they are determined by a combination of hydrological processes and politicized human interventions (Bakker, 2010). Such politicized interventions create inequalities between parts of the city that receive water in abundance and parts that lack access to it. UPE acknowledges the importance of social,

economic and political power relations and shows how water flows to the elites and not to the poor (Ranganathan, 2014; Stoler et al., 2015). UPE has elaborately discussed the role of state actors in water governance, highlighting the contested roles of managerial or technocratic approaches (Myers, 2008). UPE has successfully evaluated these approaches, raising questions of inequality, justice and poverty in the Global South (Schroeder et al., 2006; Walker, 2007), especially focusing on water flows (Swyngedouw, 1999). Keeping the power questions as central to the UPE analyses, various scholars have discussed the role of formal and informal actors in urban water regimes (Gandy, 2006; Lawhon et al., 2014). Marxist UPE scholars have used the notions of urban metabolism and flow to analyse power and critique the structure of the formal actors or the state. Mbembe (2001) discusses how constant proliferation of formal technologies of the state – budgets, contracts, job descriptions and certificates are used for meeting its covert goals.

The UPE literature has also had an important role in revealing the full range of the various alternatives, informal water regimes that are used by many urban residents, especially the poor. Informality was initially conceptualized with various interpretations, but mostly negative connotations such as being inefficient, expensive, complicated and illegal. UPE water scholars have highlighted the informal water suppliers' abilities to use their power and influence in order to break the boundaries between formal and informal water markets (Graham et al., 2013; Ranganathan, 2014).

UPE studies have also criticized the informal water regimes for their aggressive pricing, unreliable water quality, effects on peri-urban groundwater extraction, and use of agricultural water for urban purposes – highlighting conflicts and concerns of inequity and injustice for urban and peri-urban residents (Hinkfuss, 2010; Mehta et al., 2014; Vij et al., 2019; Zwartveen & Boelens, 2014). Swyngedouw (2005) relates informality to the water governance 'beyond-the-state', where various non-state actors play an important role in organizing and providing water services.

Three factors are important in understanding the increased role of informal actors in water supply regimes. First, there is widespread inability amongst the public service providers to respond to a growing demand and rapid urban growth, providing more opportunities to the small-scale private sector to become an accepted mode of water service provisioning (Brown & McGranahan, 2016). Second, with the rapid rate of urbanization, urban informality has become an accepted 'organizing logic' to meet the demands of the city dwellers (Roy, 2009). With this logic, informality appears and works not only in poverty contexts but also in highly formalized middle- or upper-class areas (Hackenbroch & Hossain, 2012). Third, a special emphasis on informal actors as part of urban water regimes has been promoted by governments themselves, supported by international donors. Increasingly the limitations of formal water service delivery have been acknowledged, making space for informal actors, although often with an implicit agenda of gradual integration and formalization (Boakye-Ansah et al., 2019). These interactions between formal and informal actors are nuanced in a critical interface, where these actors influence each other to meet their interests and priorities.

With these underlying factors, informal water modalities have become prominent in developing countries. For instance, the public infrastructure and utility services in India are unable to meet the growing city needs for domestic and industrial water (McKenzie & Ray, 2009; Saleth & Ariel, 1997). The water supply and demand gap is met by drawing groundwater from the peripheral villages and this leads to the growth of informal water

regimes that facilitate transfer of groundwater, both in terms of space (peri-urban to urban) and by sector (agriculture/residential/recreation/industries; McGregor et al., 2012; Rosegrant & Binswanger, 1994; Tacoli, 1998). Engulfing of peri-urban resources by urban water regimes contributes to groundwater depletion and water insecurity in peri-urban villages (Vij et al., 2019). An analysis of these processes is essential for addressing issues of water (in)security and (in)equity.

The interaction between formal and informal water supply regime actors in a critical interface is a result of power interplay and asymmetries, producing various uneven and conflictual water regimes. The state plays a crucial role in shaping the structure of informality. For instance, Meagher (1995), shows how the expansion of informality in Sub-Saharan Africa is not a process occurring 'outside the state' but is instead the result of an environment of 'state complicity'. By this means, informality is a mode of state regulation practised after careful consideration of the power and influence of the population group. The state actors are very closely knitted in the informal space. For instance, the power relationship between the urban residents and other actors such as the state authorities and peripheral residents changes over time. Anjaria (2006) observed state actors (officials in this case) were actively involved in modifying the relationship between the state and the population. Here, state actors gain from not legitimizing street vendors' status in order to exercise their power and exploit the vendors financially, collecting *hafta* (informal payments outside official rules). Vij et al. (2019) show that local politicians owning water tanker business in peri-urban Hyderabad have a strong influence, while the water users and water tanker suppliers within the village are oppressed. Informality is shaped and represented by constellations of power (Hackenbroch & Hossain, 2012).

Similarly, Kooy (2014) and Misra (2014) show that state structures can influence informal water regimes even though they are intimately related to the formal water regimes. For instance, when the state fails to meet the drinking water demand of the citizens, private water players come forward to fill this gap. The state allows the informal regime to establish itself and does not impose any sanctions on it for high water pricing and uncertain quality. Hence, it is imperative to understand the power dynamics between the actors operating in the critical interface. The state and its closely linked actors use their power (authority, legitimacy and control) to continue their influence over other actors, referring to the politics of informality (Kudva, 2009).

Interactions in the critical interface of urban water regimes

We want to emphasize the role of the critical interface (introduced above) using empirical illustrations from ongoing work in Nairobi and Delhi. In particular, the importance of the critical interface tends to materialize at a very local level, such as by means of actor negotiations in informal settlements (Blomkvist et al., 2020).

The example of ongoing work in Nairobi in one of the informal settlements in Mathare (approximately 5 km from the centre of Nairobi) illustrates how a critical interface forms on the ground. In this settlement, we identify a critical interface between the formal water regime (represented by water provisioning by the Nairobi City Water and Sewerage Company) and the informal water regime (comprised of private individual water sellers and youth groups supplying water by cart water vendors). This is a critical interface characterized by conflicts

regularly expressed as sources of frustration by municipal water officials, one of whom mentioned that ‘even where we have managed to introduce our services, there still is a very high risk for vandalism’ (Sitoki et al., 2020). From the perspective of the formal water regime, there is always the suspicion that acts of vandalism are caused by the informal water regime in order to divert customers to their own water connection points.

However, in other instances we observe that the critical interface is shaped by cooperation as opposed to conflict. In referring to cooperation, we draw attention here to the role of institutions – the norms, practices and codes of conduct – that bind people together to accomplish a common goal. An institutional analysis is central to both UPE analyses of power and STS analyses of regimes and is further relevant to how the critical interface functions (Fuenfschilling & Truffer, 2016; Monstadt & Schramm, 2017). By observing what water users are doing in a local context helps to reveal institutional norms for expanding the reach of the formal water regime by means of an informal water regime. For instance, a few years ago the village council of Rawta village (Delhi) gathered to find a solution to the problem of water scarcity. They decided that a private water vendor would invest in a network of pipes in the village, connecting it to his farm’s submersible, to supply water to village residents, constituting an informal water regime. The vendor laid down a semi-covered network of polyvinyl chloride (PVC) pipes to connect the household and an underground pipe to provide water to these pipes. The vendor provides water by diverting the water in different directions in the village by rotating the valves in the underground pipe. Water is pumped daily for 10–15 min to each household, sufficient to deliver the predetermined volume of water, with a fixed charge of 200 INR/month (Narain et al., 2023). The reality often is that the formal regime (the Delhi Jal Board) can be compelled to accept this arrangement even though in state parlance an informal water regime is technically illegal. The junior engineer working for the Delhi Jal Board entrusted with Rawta village expressed the view that the provisioning of water by the private groundwater vendor is illegal and needed to be checked. However, this institutional arrangement allows the formal water regime to be ambidextrous, mandating and gradually integrating actors from outside of the regime to operate in designated areas which otherwise would create new challenges for it.

Apart from actors and institutions, a focus on the critical interface is underscored by an understanding of infrastructure heterogeneity when it comes to water supply infrastructure (Lawhon et al., 2018, 2022). In contrast to planning discourses that tend to emphasize expansion of ‘piped’ water infrastructure, drinking water provision takes place through ‘piped’ and ‘non-piped’ technologies (pipes, water extraction pumps, reverse osmosis plants, water tankers and water storage structures) that are operated by formal and informal water regimes (Narain et al., 2023). Particularly in low-income urban settlements, these technologies form a critical interface to fulfil basic water needs. Recent work suggests that the formal regime adapts its technology to smaller configurations (e.g., water kiosks) in order to reach better areas that are traditionally served by the informal regime (Nzengya, 2018; Schwartz et al., 2017). Such a technological intervention can be seen as an effort to mimic informal modes of provision yet can be heavily contested by the informal regime that can even try to sabotage its success (Blomkvist et al., 2020). In this way, technology even when designed to be adapted to the local context, becomes in reality viewed as a ‘foreign’ entity meant to disrupt the status quo (Boakye-Ansah et al., 2019). On the other hand, technology can have a cooperative

dimension as well in the critical interface. Particularly from the perspective of the water users, choices regarding whether to use the formal or the informal regime are informed by an implicit acceptance of heterogeneity and considerations such as water quantity and quality and pricing. This was described as such by a water user from Mathare, ‘We use all these sources of water. Water from pre-paid water dispensers¹ is cheap and I use it for washing clothes but I use this other one for drinking’ (Sitoki et al., 2020). It was often reported that as long as there is water available at various informal water points, users tend to accept to pay a higher price for the water, as this particular water user from Mathare mentioned, ‘Even though the PPD [pre-paid dispenser] water is far cheaper, we don’t mind paying for 5 Kenyan shillings for this other one’ (Sitoki et al., 2020). Water users tend to recognize very well the different technologies and can adapt their water strategies according to the strengths and weaknesses of each water regime in their locality (Alba et al., 2020; Lawhon et al., 2018). That is how local communities choose among different technologies to meet their daily water needs.

Conclusions

In this literature review we have examined two important bodies of literature that are engaged with challenges of water provision in the Global South. These bodies of literature have been productively discussed in previous literature reviews as well that describe the particular strengths of bringing these two fields into closer conversation with each other (Furlong, 2014; Lawhon & Murphy, 2012). Drawing insights from this work, and our own review, we want to extend this discussion by showing that these two literatures can also learn from each other regarding the interaction of formal and informal water provision in cities of the Global South (Figure 1).

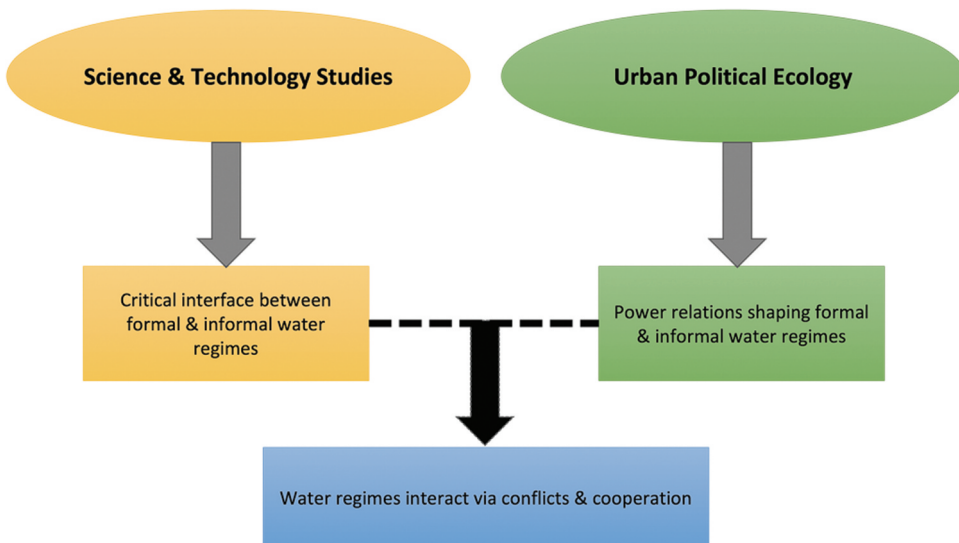


Figure 1. Schematic summary of the key concepts and their interrelationships in order to understand formal and informal water regimes.

A positive trend in the STS field which has been highlighted is the opening up of the scope of study to include deeper theorizations of cases in the Global South. We see that here STS scholars are learning from UPE scholars by considering socio-technical systems as part of more heterogeneous processes of regime formation as opposed to homogeneous as it has been previously conceived for quite some time in Northern settings (Lawhon et al., 2018). This also creates a different type of conversation amongst STS scholars about the particular meaning and implication of regimes in Global South settings (van Welie et al., 2018). Therefore, critical issues that have had their place in UPE for a long time when studying water provision, such as the role of geographical factors and power relations are now increasingly prominent in STS debates. These types of developments also have implications for the role of water provision becoming a more central theme in this literature.

We equally find that STS has an important role in providing new ideas and insights for UPE scholars working on water provision with an interest in the interplay of formality and informality. In UPE the distinction between formal and informal water regimes as well as piped and non-piped water supply tends to be more blurred than in the STS literature (Ahlers et al., 2014; Schwartz & Tutusaus Luque, 2015). Gaining insights from STS approaches, we would also like to highlight that formal and informal water regimes do demonstrate certain unique characteristics with regard to the actors, institutions and technologies employed. This aspect of our conceptual work will appeal to practitioners and scholars working on urban water governance. Formal water regimes play a critical role in providing urban water services; however, informal regimes are critical in innovating local and small scale technologies, institutions (every day water usage practices), providing a unique opportunity for tackling future uncertain and complex challenges. Water practitioners and scholars may want to take a cue from these heterogeneous configurations of formal and informal water regimes for designing future urban water governance programmes and projects. Further attention to these features of formal and informal regimes may be attended to by UPE scholars. Insights from the STS literature also direct attention to how involved actors can cooperate in order to make water provision work. We therefore want to highlight that both conflict and cooperation can be important lenses through which UPE can become more concrete about the different ways in which water regimes interact in practice (Alba et al., 2020; Vij et al., 2018). Work around the critical interface as a boundary space of interaction across formal and informal water regimes can be of added significance in the context of UPE debates on water provision.

Note

1. Referring to formalized water provision, in this case since pre-paid dispensers are introduced by the Nairobi City Water and Sewerage Company to bridge the water supply gap in the informal settlements.

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References

- Ahlers, R., Cleaver, F., Rusca, M., & Schwartz, K. (2014). Informal space in the urban waterscape: Disaggregation and co-production of water services. *Water Alternatives*, 7(1), 1–14. <https://www.water-alternatives.org/index.php/all-abs/230-a7-1-1/file>
- Alba, R., Kooy, M., & Bruns, A. (2020). Conflicts, cooperation and experimentation: Analysing the politics of urban water through Accra’s heterogeneous water supply infrastructure. *Environment and Planning E: Nature and Space*, 2514848620975342. <https://doi.org/10.1177/2514848620975342>
- Anjaria, J. S. (2006). Street Hawkers and public space in Mumbai. *Economic and Political Weekly*, 41(21), 2140–2146. <https://www.jstor.org/stable/4418270>
- Bakker, K. (2007). Trickle down? Private sector participation and the pro-poor water supply debate in Jakarta, Indonesia. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, 38(5), 855–868. <https://doi.org/10.1016/j.geoforum.2005.11.011>
- Bakker, K. (2010). *Privatizing water: Governance failure and the world’s urban water crisis*. Cornell University Press.
- Blomkvist, P., & Nilsson, D. (2017). On the need for system alignment in large water infrastructure: Understanding infrastructure dynamics in Nairobi, Kenya. *Water Alternatives*, 10(2), 283–302. <https://www.water-alternatives.org/index.php/alldoc/articles/vol10/v10issue2/356-a10-2-6/file>
- Blomkvist, P., Nilsson, D., Juma, B., & Sitoki, L. (2020). Bridging the critical interface: Ambidextrous innovation for water provision in Nairobi’s informal settlements. *Technology in Society*, 60, 101221. <https://doi.org/10.1016/j.techsoc.2019.101221>
- Boakye-Ansah, A. S., Schwartz, K., & Zwartveen, M. (2019). From rowdy cartels to organized ones? The transfer of power in urban water supply in Kenya. *European Journal of Development Research*, 31(5), 1246–1262. <https://doi.org/10.1057/s41287-019-00209-3>
- Brown, D., & McGranahan, G. (2016). The urban informal economy, local inclusion and achieving a global green transformation. *Habitat International*, 53, 97–105. <https://doi.org/10.1016/j.habitatint.2015.11.002>
- Budds, J., & McGranahan, G. (2003). Are the debates on water privatization missing the point? Experiences from Africa, Asia and Latin America. *Environment and Urbanization*, 15(2), 87–114. <https://doi.org/10.1177/095624780301500222>
- Collignon, B., & Vézina, M. (2000). *Independent water and sanitation providers in African cities*. World Bank, Water and Sanitation Program. <https://nl.ircwash.org/sites/default/files/202.6-00IN-18938.pdf>

- Fuenfschilling, L., & Binz, C. (2018). Global socio-technical regimes. *Research Policy*, 47(4), 735–749. <https://doi.org/10.1016/j.respol.2018.02.003>
- Fuenfschilling, L., & Truffer, B. (2014). The structuration of socio-technical regimes – Conceptual foundations from institutional theory. *Research Policy*, 43(4), 772–791. <https://doi.org/10.1016/j.respol.2013.10.010>
- Fuenfschilling, L., & Truffer, B. (2016). The interplay of institutions, actors and technologies in socio-technical systems – An analysis of transformations in the Australian urban water sector. *Technological Forecasting and Social Change*, 103, 298–312. <https://doi.org/10.1016/j.techfore.2015.11.023>
- Furlong, K. (2014). STS beyond the ‘modern infrastructure ideal’: Extending theory by engaging with infrastructure challenges in the South. *Technology in Society*, 38, 139–147. <https://doi.org/10.1016/j.techsoc.2014.04.001>
- Gandy, M. (2006). *Water, sanitation and the modern city: Colonial and post-colonial experiences in Lagos and Mumbai (HDOCPA-2006-06)*. Human Development Report Office (HDRO), United Nations Development Programme (UNDP). <https://EconPapers.repec.org/RePEc:hdr:hdocpa:hdocpa-2006-06>
- Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, 33(6–7), 897–920. <https://doi.org/10.1016/j.respol.2004.01.015>
- Geels, F. W., & Kemp, R. (2007). Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. *Technology in Society*, 29(4), 441–455. <https://doi.org/10.1016/j.techsoc.2007.08.009>
- Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, 36(3), 399–417. <https://doi.org/10.1016/j.respol.2007.01.003>
- Goubert, J. P. (1989). *The conquest of water: The advent of health in the industrial age*. Polity Press.
- Graham, S., Desai, R., & McFarlane, C. (2013). Water Wars in Mumbai. *Public Culture*, 25(1), 115–141. <https://doi.org/10.1215/08992363-1890486>
- Hackenbroch, K., & Hossain, S. (2012). ‘The organised encroachment of the powerful’ – Everyday practices of public space and water supply in Dhaka, Bangladesh. *Planning Theory & Practice*, 13(3), 397–420. <https://doi.org/10.1080/14649357.2012.694265>
- Hansen, U. E., Nygaard, I., Romijn, H., Wiczorek, A., Kamp, L. M., & Klerkx, L. (2018). Sustainability transitions in developing countries: Stocktaking, new contributions and a research agenda. *Environmental Science & Policy*, 84, 198–203. <https://doi.org/10.1016/j.envsci.2017.11.009>
- Hinkfuss, S. (2010). The role of the informal sector in equitable water distribution: A case study of the tanker market in Ayn al-Basha, Jordan. Doctoral dissertation, Harvard University.
- Hodson, M., & Marvin, S. (2010). Can cities shape socio-technical transitions and how would we know if they were? *Research Policy*, 39(4), 477–485. <https://doi.org/10.1016/j.respol.2010.01.020>
- Hughes, T. P. (1993). *Networks of power: Electrification in western society, 1880–1930*. JHU Press.
- Karpouzoglou, T., & Vij, S. (2017). Waterscape: A perspective for understanding the contested geography of water. *Wiley Interdisciplinary Reviews: Water*, 4(3), e1210. <https://doi.org/10.1002/wat2.1210>
- Kooy, M. (2014). Developing informality: The production of Jakarta’s Urban waterscape. *Water Alternatives*, 7(1), 35–53. <https://www.water-alternatives.org/index.php/volume7/v7issue1/232-a7-1-3/file>
- Kudva, N. (2009). The everyday and the episodic: The spatial and political impacts of urban informality. *Environment & Planning A*, 41(7), 1614–1628. <https://doi.org/10.1068/a41101>
- Lawhon, M., Ernstson, H., & Silver, J. (2014). Provincializing urban political ecology: Towards a situated UPE through African urbanism. *Antipode*, 46(2), 497–516. <https://doi.org/10.1111/anti.12051>
- Lawhon, M., & Murphy, J. T. (2012). Socio-technical regimes and sustainability transitions: Insights from political ecology. *Progress in Human Geography*, 36(3), 354–378. <https://doi.org/10.1177/03091325111427960>

- Lawhon, M., Nilsson, D., Silver, J., Ernstson, H., & Lwasa, S. (2018). Thinking through heterogeneous infrastructure configurations. *Urban Studies*, 55(February4), 004209801772014. <https://doi.org/10.1177/0042098017720149>
- Lawhon, M., Nsangi Nakyagaba, G., & Karpozoglou, T. (2022). Towards a modest imaginary? Sanitation in Kampala beyond the modern infrastructure ideal. *Urban Studies*. <https://doi.org/10.1177/00420980211064519>
- Mbembe, A. (2001). *On the Postcolony*. University of California Press.
- McDonald, D. A., & Swyngedouw, E. (2019). The new water wars: Struggles for remunicipalisation. *Water Alternatives*, 12(2), 322–333. <https://www.water-alternatives.org/index.php/alldoc/articles/vol12/v12issue3/528-a12-2-11/file>
- McGregor, D., Simon, D., & Thomson, D. (2012). *The peri-urban interface: Approaches to sustainable natural and human resource use*. Routledge.
- McKenzie, D., & Ray, I. (2009). Urban water supply in India: Status, reform options and possible lessons. *Water Policy*, 11(4), 442–460. <https://doi.org/10.2166/wp.2009.056>
- Meagher, K. (1995). Crisis, informalization and the urban informal sector in sub-Saharan Africa. *Development and Change*, 26(2), 259–284. <https://doi.org/10.1111/j.1467-7660.1995.tb00552.x>
- Mehta, L., Allouche, J., Nicol, A., & Walnycki, A. (2014). Global environmental justice and the right to water: The case of peri-urban Cochabamba and Delhi. *Geoforum; Journal of Physical, Human, and Regional Geosciences*, 54, 158–166. <https://www.sciencedirect.com/science/article/abs/pii/S0016718513001309?via%3Dihub>
- Melosi, M. V. (2000). *The sanitary city: Urban infrastructure in America from colonial times to the present*. Johns Hopkins University Press.
- Misra, K. (2014). From formal–informal to emergent formalisation: Fluidities in the production of urban waterscapes. *Water Alternatives*, 7(1), 15–34. <https://www.water-alternatives.org/index.php/volume7/v7issue1/231-a7-1-2/file>
- Monstadt, J., & Schramm, S. (2017). Toward the networked city? Translating technological ideals and planning models in water and sanitation systems in Dar es Salaam. *International Journal of Urban and Regional Research*, 41(1), 104–125. <https://doi.org/10.1111/1468-2427.12436>
- Myers, G. A. (2008). Peri-urban land reform, political–economic reform, and urban political ecology in Zanzibar. *Urban Geography*, 29(3), 264–288. <https://doi.org/10.2747/0272-3638.29.3.264>
- Narain, V., Vij, S., & Karpozoglou, T. (2023). Demystifying piped water supply: Formality and informality in (peri)urban water provisioning. *Urban Studies*. <https://journals.sagepub.com/doi/full/10.1177/00420980221130930>
- Nilsson, D., & Blomkvist, P. (2021). Is the self-read water meter a pro-poor innovation? Evidence from a low-income settlement in Nairobi. *Utilities Policy*, 68, 101143. <https://doi.org/10.1016/j.jup.2020.101143>
- Nzengya, D. M. (2018). Improving water service to the urban poor through delegated management: Lessons from the city of Kisumu, Kenya. *Development Policy Review: The Journal of the Overseas Development Institute*, 36(2), 190–202. <https://doi.org/10.1111/dpr.12361>
- Page, B. (2005). Paying for water and the geography of commodities. *Transactions of the Institute of British Geographers*, 30(3), 293–306. <https://doi.org/10.1111/j.1475-5661.2005.00172.x>
- Ramos-Mejía, M., Franco-García, M. L., & Jauregui-Becker, J. M. (2018). Sustainability transitions in the developing world: Challenges of socio-technical transformations unfolding in contexts of poverty. *Environmental Science & Policy*, 84(April 2017), 217–223. <https://doi.org/10.1016/j.envsci.2017.03.010>
- Ranganathan, M. (2014). ‘Mafias’ in the waterscape: Urban informality and everyday public authority in Bangalore. *Water Alternatives*, 7(1), 89–105. <https://www.water-alternatives.org/index.php/alldoc/articles/vol7/v7issue1/235-a7-1-6/file>
- Rip, A., & Kemp, R. (1998). Technological change. In S. Rayner & E. L. Malone (Eds.), *Human choice and climate change* (Vol. II, pp. 327–399). Battelle Press.
- Rosegrant, M. W., & Binswanger, H. P. (1994). Markets in tradable water rights: Potential for efficiency gains in developing country water resource allocation. *World Development*, 22(11), 1613–1625. [https://doi.org/10.1016/0305-750X\(94\)00075-1](https://doi.org/10.1016/0305-750X(94)00075-1)

- Roy, A. (2009). Why India cannot plan its cities: Informality, insurgence and the idiom of urbanization. *Planning Theory*, 8(1), 76–87. <https://doi.org/10.1177/1473095208099299>
- Saleth, M. *D. R., & Ariel. (1997). *Satisfying urban thirst – Water supply augmentation and pricing policy in Hyderabad City, India* (No. WTP395; p. 1). The World Bank. <http://www-wds.worldbank.org/external/default/WDSContentServer/WDS/00016718505000618>
- Schroeder, R. A., Martin, K. S., & Albert, K. E. (2006). Political ecology in North America: Discovering the third world within? *Geoforum; Journal of Physical, Human, and Regional Geosciences*, 37(2), 163–168. <https://www.sciencedirect.com/science/article/abs/pii/S0016718505000618>
- Schwartz, K., Tutusaus Luque, M., Rusca, M., & Ahlers, R. (2015). (In)formality: The meshwork of water service provisioning. *WIREs Water*, 2(1), 31–36. <https://doi.org/10.1002/wat2.1056>
- Schwartz, K., Tutusaus, M., & Savelli, E. (2017). Water for the urban poor: Balancing financial and social objectives through service differentiation in the Kenyan water sector. *Utilities Policy*, 48, 22–31. <https://doi.org/10.1016/j.jup.2017.08.001>
- Sitoki, L., Juma, B., Nekesa, G., & Karpouzoglou, T. (2020). *Making the water flow: Conflict(s) and cooperation between formal and informal urban water regimes in Africa and Asia* (No. 1). KTH Royal Institute of Technology. <https://www.kth.se/philhist/historia/forskning/environmental-humani/making-the-water-flow-1.876890>
- Smiley, S. L. (2020). Heterogeneous water provision in Dar es Salaam: The role of networked infrastructures and alternative systems in informal areas. *Environment and Planning E: Nature and Space*. <https://journals.sagepub.com/doi/abs/10.1177/2514848620908194>.
- Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, 34(10), 1491–1510. <https://doi.org/10.1016/j.respol.2005.07.005>
- Stoler, J., Tutu, R. A., & Winslow, K. (2015). Piped water flows but sachet consumption grows: The paradoxical drinking water landscape of an urban slum in Ashaiman, Ghana. *Habitat International*, 47, 52–60. <https://doi.org/10.1016/j.habitatint.2015.01.009>
- Sultana, F. (2020). Embodied intersectionalities of urban citizenship: Water, infrastructure, and gender in the Global South. *Annals of the Association of American Geographers. Association of American Geographers*, 110(5), 1407–1424. <https://doi.org/10.1080/24694452.2020.1715193>
- Swyngedouw, E. (1999). Modernity and hybridity: Nature, regeneracionismo, and the production of the Spanish waterscape, 1890–1930. *Annals of the Association of American Geographers. Association of American Geographers*, 89(3), 443–465. <https://doi.org/10.1111/0004-5608.00157>
- Swyngedouw, E. (2005). Dispossessing H₂O: The contested terrain of water privatization. *Capitalism Nature Socialism*, 16(1), 81–98. <https://www.tandfonline.com/doi/abs/10.1080/1045575052000335384?journalCode=rcns20>
- Swyngedouw, E. (2007). Technonatural revolutions: The scalar politics of Franco's hydro-social dream for Spain, 1939?1975. *Transactions of the Institute of British Geographers*, 32(1), 9–28. <https://doi.org/10.1111/j.1475-5661.2007.00233.x>
- Tacoli, C. (1998). Rural–urban interactions: A guide to the literature. *Environment and Urbanization*, 10(1), 147–166. <https://doi.org/10.1177/095624789801000105>
- van Welie, M. J., Cherunya, P. C., Truffer, B., & Murphy, J. T. (2018). Analysing transition pathways in developing cities: The case of Nairobi's splintered sanitation regime. *Technological Forecasting and Social Change*, 137, 259–271. <https://doi.org/10.1016/j.techfore.2018.07.059>
- van Welie, M. J., Truffer, B., & Gebauer, H. (2019). Innovation challenges of utilities in informal settlements: Combining a capabilities and regime perspective. *Environmental Innovation and Societal Transitions*, June 2018, 0–1. <https://www.sciencedirect.com/science/article/abs/pii/S0040162517303323>
- Venkatachalam, L. (2015). Informal water markets and willingness to pay for water: A case study of the urban poor in Chennai City, India. *International Journal of Water Resources Development*, 31(1), 134–145. <https://doi.org/10.1080/07900627.2014.920680>
- Vij, S., John, A., & Barua, A. (2019). *Whose water? Whose profits? The role of informal water markets in groundwater depletion in peri-urban Hyderabad*. *Water Policy*. <https://iwaponline.com/wp/article-abstract/doi/10.2166/wp.2019.129/69549/Whose-water-Whose-profits-The-role-of-informal>

- Vij, S., Narain, V., Karpouzoglou, T., & Mishra, P. (2018). From the core to the periphery: Conflicts and cooperation over land and water in periurban Gurgaon, India. *Land Use Policy*, 76(May), 382–390. <https://doi.org/10.1016/j.landusepol.2018.04.050>
- Walker, P. A. (2007). Political ecology: Where is the politics? *Progress in Human Geography*, 31(3), 363–369. <https://doi.org/10.1177/0309132507077086>
- Wieczorek, A. J. (2018). Sustainability transitions in developing countries: Major insights and their implications for research and policy. *Environmental Science & Policy*, 84, 204–216. <https://doi.org/10.1016/j.envsci.2017.08.008>
- William, D., Shuang, S., & Yu, C. (2018). The role of informal small-scale water supply system in resolving drinking water shortages in peri-urban Dar es Salaam. *Tanzania. Applied Geography*, 92(July 2017), 112–122. <https://doi.org/10.1016/j.apgeog.2018.02.001>
- Zwarteveen, M., & Boelens, R. (2014). Defining, researching and struggling for water justice: Some conceptual building blocks for research and action. *Water International*, 39(2), 143–158. <https://doi.org/10.1080/02508060.2014.891168>