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Water technology, knowledge and power. Addressing them simultaneously

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Abstract

This review focuses on how water knowledge and technology are linked to power relations when they shape water access, sharing and distribution. It examines how scholars have tackled this issue explicitly or implicitly. To do this, the paper first discusses the way knowledge and technology are intimately intertwined. Since knowledge and technology are never produced in a sociopolitical vacuum, it goes on to discuss how they embed and produce power relations. This article particularly highlights the way the concept of co-production has been used to address these issues by focusing on how boundaries and categories are made. Lastly, the review suggests four lines of research to further explore co-production processes: i) understanding the political construction of scales of water use and access; ii) identifying the diversity and dynamics of the relations towards water that societies deploy, iii) grasping the way framings and paradigms have been historically shaped, and iv) lastly, pursuing the simultaneous analysis of the political and material dimensions of water.

Introduction

We posit that water technology, power relations and knowledge about water are fully interlinked. Indeed, knowledge allows us to construct technology, but technology also largely motivates our production of knowledge: science does not precede the development of technology (1,2). Knowledge and technology are therefore linked in a nonlinear fashion. For instance, the Navier-Stocke equation theorizes fluid mechanics. Yet Navier, a nineteenth-century French civil engineer at the Ponts et Chaussées (Bridges and Roads State Corps), developed it while also designing hydraulic infrastructures. He sought to match mathematical equations with physical considerations and empirical observations, and by doing so, to contribute to the production of a new engineering ethos in which the truth is obtained when a general theory fits in with specific practices (3). Moreover, both knowledge and technology embed, maintain and produce power relations while shaping access to and control of water or favoring specific actors or representations of water. For instance, a high-tech, computer-driven irrigation system using pressurized pipes and drip irrigation requires a greater investment and a higher level of formal education from its users than a traditional, open-air canal system. These two irrigation technologies do not directly or indirectly benefit or harm the same actors. The high-tech system empowers the farmer capable of investing in it and of manipulating it. This is a direct benefit. It also renders irrigation more 'efficient' since a larger proportion of the water applied to a field is used for the transpiration of cultivated plants, while water infiltration in the soil is reduced. In doing this, the high-tech system may stop the seepage that occurred through the dirt canals the farmer may have previously used. This may dry out the neighboring village's well which relied on this seepage. This indirect negative impact on the users of the neighboring village's well is produced by the high-tech system. The way irrigation technologies modify the circulation between surface and subsurface waters, as well as water uses and access, has been reported in many regions (4,5). Similarly,

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knowledge about water in agriculture often represents this element only as a production variable. To ignore the numerous roles water plays within local practices sustains policies that empower actors who do not rely on such practices.

There are multiple forms of water knowledge, various practices and roles associated with water that can be of different orders: cultural, environmental, economic, recreational, social, etc. (6,7). These are not mutually exclusive and are intertwined: one should not take for granted the dichotomy between the “market” and the “non-market”, between “subsistence agriculture” and “commercial agriculture”, or between public and private property, etc. Specific and usually simplistic economic representations of water also tend to dominate the debate. These representations are in turn largely influenced by the prevailing paradigms in force in the broader world economy. For instance, the 1990s saw the advent of new discourses on water as the international neoliberal agenda spread further. Such discourses led to delegating water services to the private sector, represented by a group of multinational drinking-water delivery companies, in the name of their managerial “efficiency”. Such discourses favored the production of “water pricing” knowledge dominated by neoclassical economics and also generated significant social contestations (8).

The aim of this article is to understand how literature has addressed the relations between water knowledge, technology and power. Few scholars have explicitly mobilized these three dimensions simultaneously. The co-production concept developed within the field of “science studies” appears to be useful for understanding how water knowledge, technology and power relations produce each other mutually.

First, we examine the links between water knowledge and technology. Second, we study their links to power (section 1). The review then explores the literature that addresses water, technology, knowledge and power as co-productions, whether explicitly or not (section 2). Lastly, this review briefly outlines new lines of research that have emerged from the analysis. It proposes harnessing new concepts, such as the “paracommons” and older ones such as tenure, which have not yet been appropriated by the literature on water (section 3).

LINKING KNOWLEDGE, TECHNOLOGY AND POWER

Methodology

This article is based on a review of the literature in the field of humanities and social science. Initially, we carried out a quantitative bibliometric search using two databases: Scopus and Web of Science. This work revealed that the words we had chosen as keywords for our own research, i.e. “water”, “knowledge”, “technology”, “power relations” had hardly been used together by scholars in the title, abstract or keywords of their referenced articles. This observation is consistent with that of the editors of a special issue on water knowledge, technology and power who had difficulty in getting the authors to explicitly develop the three topics together (9). Given our different backgrounds and reading in anthropology, political science, sociology, political ecology and, science and technology studies (STS), we knew of papers that implicitly addressed this relationship. We therefore privileged a qualitative analysis of our own bibliography and of any relevant additional papers we had identified during our preliminary quantitative study.

Links between knowledge and technologies

Knowledge about water may pertain to a variety of academic disciplines or may be vernacular, in which case it rarely exists in written form but remains systematically embedded in practices and technologies. This knowledge integrates specific representations of water (as a resource, as part of spiritual life or otherwise) and of its access, allocation and management.

Anthropologists have highlighted the institutions, rules and techniques governing so-called “traditional irrigation” and implicitly involving kinship, caste, class, socio-political relations or religious dimensions. For instance, kinship or lineage shapes the design of canals and the distribution of water in Tunisia (10), Nepal (11) or Sri Lanka (12). In Bali temples, religious values lie at the very center of collective irrigation management, with priests coordinating water distribution and maintenance of kilometers of tunnels and canals in collaboration with farmers’ associations. The latter, organized into networks, are indeed linked to ‘water temples’ that are structured hierarchically up to regional level, providing a centralized management aspect (13). Even simple technologies, such as earth dams and diversion canals, embed complex and diverse knowledge (14). Sudanese nomadic herdsman’s use of simple watering holes is governed by knowledge of clan relations (15). Since the 1980s, scholars in irrigation studies have underlined the continuous interaction between human and material dimensions and have also gone one step further in analyzing them together as inseparable dimensions (16).

STS scholars have demonstrated the manner modern science has always been mediated by technologies, coining the term “technosciences” to grasp such processes. Political struggles and the technology that is available thus shape the production of scientific knowledge. Everywhere minimum flow requirements are “scientifically” determined for river ecosystem restoration. Yet this approach has only been able to develop because technology in the form of dams and monitoring systems that generate hydrological data has helped to control river flows. The negative effects of dams have been diversely integrated in political and scientific agendas: some have been ignored while others have oriented research towards depolluting stagnant water or have engendered new rules and regulations.

Links to power

First, knowledge and technology shape the access to and the control of water, and when doing so produce and refract power relations in very different ways. The diverse actors involved deserve close scrutiny: they may be donors, governments, inter-State organizations, non-governmental organizations, public agencies, independent consultants, infrastructure building companies, water users and their representatives, etc. The choice of technology and its related social arrangements may reinforce social and religious orders (17), exacerbate asymmetries between upstream and downstream users in gravity-fed systems (18) or, conversely, attenuate such asymmetries (11). Irrigation or drinking-water systems designed by nation states or local governments require a huge diversity of technology that mediates in various ways the relationship between users and the political rule (19,20). Accessing new technologies such as pumps or social capital, such as clientelist connections with government officials, may also transform power relations (21,22).

Second, technology or scientific knowledge is never produced in a power vacuum. Yet scientists and engineers often deploy much energy to represent their practices, claims and technologies as unquestionable. One usually notices the way technology embeds, maintains and produces power relations more readily than the way knowledge does. Yet the very way in which one formulates research questions is permeated with power relations that are considered legitimate. These power

relations are rarely precisely examined because, since the latter are regarded as legitimate, one tends to take them for granted (23)—criticism that can be applied to any research, including ours. Processes of “naturalization” are also processes of “depoliticization”. In other words, a movement allowing an entity to become “natural” also corresponds to a movement that dissociates scientific claims from the power relations in which they are embedded, i.e. to a movement that is able to effectively silence criticism. For instance, the watershed has become the preferred unit for studying and governing water, a central tenet of most State-led water policies around the world. One can see the advent of the watershed as a political construction involving effective alliances between hydrologists, engineers and nation states in order to sustain the damming of rivers, to address in a particular manner water quality, or conflicts over water sharing (24) to the expense of other forms of local political or social organizations. Society is indeed not usually organized according to hydrological boundaries. Elected representatives, for instance, do not generally rely on watersheds to maintain or build their political legitimacy. Instead, social groups in given geographical settings refer to different systems that combine several components, some of them relating to rivers, others not. Finally, the dominant representation of the water cycle is actually very situated: it may well represent water circulation under temperate climates. It also normalizes surface water abundance, minimizes subsurface water circulation and tends to portray temporary flow regimes, such as wadis, as problematic. Another example can be found in the recurrent use of technologies such as dams or desalination since the 1960s at least, as a promise of an unlimited water supply, leading to key political questions about water use and sharing being shelved (25–27).

Finally, the links between water knowledge and technology on the one hand and power on the other lie in the continuous interactions between the construction of “natural” and “social” orders (28). Indeed, scholars in the field of STS have demonstrated the unavoidable interplay between our representation of nature and the way in which we wish to govern it, coining the term “co-production” to describe this. This concept can allow us to address dichotomies critically, such as traditional irrigation versus modern irrigation, indigenous knowledge versus scientific knowledge, small irrigation systems versus large irrigation systems, private water management versus public water management. Instead of taking these dichotomies for granted and regarding them as commonplace, the concept of co-production helps us to analyze them as the result of collective, complex efforts to draw boundaries, to shape categories and in doing so to distribute resources and constraints, and to create and deny rights. D. Pestre (29) distinguishes two main types of research orientations in science studies that address these issues. On the one hand, scholars who mobilize the “actor-network theory” (ANT) tend to emphasize social fluidity and society’s rearrangement capacities, and indirectly minimize power asymmetries as if the world were politically flat. On the other hand, some scholars, particularly those studying the transnational history of science and technology tend to produce a macro-social and political analysis that questions the depth and importance of social reconfigurations. Following Pestre, we postulate that these two interpretative frameworks can be heuristically productive. They do not necessarily have to be mutually exclusive. What is at stake today is finding ontologies and research methods that allow them both to be maintained(29).

KNOWLEDGE, TECHNOLOGIES AND POWER AS CO-PRODUCTIONS

Let us now examine the literature on water that explores, whether implicitly or explicitly, the role of power in the co-production of water knowledge and technology. This second section is divided into five sub-sections. The first subsection examines research that focuses on how knowledge and

technology evolve as a result of power dynamics. The second discusses how knowledge and technologies embed and maintain power relations within co-production processes. The third explores the way knowledge and technologies circulate. The fourth examines the way in which these often render political choices 'natural'. The last sub-section discusses research that focuses on how conflicts over knowledge and technologies reveal broader political conflicts.

Product of dynamic power relations

Studying knowledge and technology "in the making" (30) is a good opportunity to grasp how innovation is grounded in the dynamics of power relations. In a Tunisian oasis for example, it was only once lineages had lost their power over water management that colonial engineers succeeded in installing a rigid dividing weir that modified water distribution and ended negotiations between farmers (17). Conversely, in a large South Indian irrigation system farmers vandalize infrastructures or illicitly copy keys for operating irrigation gates to seize control of the water (31). Technology is never imposed on a territory by the higher authorities with no reaction or resistance from local actors or with no alliance or compromise with them. For instance, State-led agrarian reforms may compel water users to change their practices. However, State engineers implementing them may have to adapt to local preferences and to integrate local knowhow to carry through their projects. A good illustration of this is the modernizing hydraulic program led by the *Canal de Provence* in the South of France in the 1960s and 1970s (32). In South India, in the early 1970s, huge power asymmetries between farmers prompted the local landowning elite to unilaterally modify the (tank) irrigation infrastructure so that it would meet the agronomic water demand for a new variety of rice they wished to grow. The Indian government and the main actors of the official development aid promoted this rice as one of the key instruments of the "green revolution". In other words, the variable that farmers decided to adjust was the hydraulic infrastructure so that it created optimal conditions for the new rice variety to be the most productive, thanks to a continuous flow of water in the fields, thus putting an end to the previous ancient rotational distribution. Landowners whose fields were located upstream of the irrigation system wielded enough power to destroy canals and sluice-operating mechanisms, to capture the water flow previously directed downstream and thus to satisfy their vested interests, with no particular resistance (33).

These examples illustrate the way knowledge and technologies evolve according to power relations between water users, between users and engineers involved in infrastructure management, and between villagers and donors involved in the funding of the infrastructure. Such power relations also take place in broader sociopolitical contexts.

Co-production processes

The term co-production defines the interaction between the construction of our representation of nature and the construction of the society within which we function. The co-production of water knowledge and technology is complex and deserves further attention. For instance, when analyzing the construction of water as an object of government in California between 1850 and 1915, Caroll shows the historical process that led water to become a "boundary object" between science and governance. He studies the coproduction process that lent significance both (i) to the conceptualization of water as a resource and (ii) to the modern technoscientific Californian State. This meant a shift in the representation of water: from multiple and diverse water issues to a single water problem with many facets such as land reclamation, flood control, hydraulic mining or inland

navigation which is to be governed on a watershed scale (34). From the 1930s onwards, the US Army Corps of Engineers and the Bureau of Reclamation designed dams wherever the terrain permitted. This stemmed from a specific “social order” where the American State sought to control entire river courses. This prompted a “natural order” where hydrologists dominated the construction of a scientific water discourse. Such a co-production therefore privileged an alliance between hydrologists and the State. The former supplied the necessary data to build the dams required by the American government. The State provided for the creation of chairs of hydrology at several universities. Later, when President Carter contested 19 large dam projects, the opposition he unleashed led to a transformation of this co-production process. Young environmentalists, sociologists and economists joined the Bureau of Reclamation and opposed the “old guard” of engineers to assess whether alternatives to the initial project might be cheaper (26). This led to a rise in the hegemony of commensuration and rational choice methodologies in water governance.

In international and global contexts, technical expertise, colonialism and later “development” co-produced each other because they provided mutual representations of water and its legitimate management. For instance, Mitchell analyzes how the depoliticization of the Egyptian economy, that is the use of economics as a purely technical instrument, coincides with the transformation of Egypt into an object of development, thus hiding the complex networks of dependence within Egypt or between Egypt and the USA. He analyzes the role played by “expertise”, in particular from social science, in the making of “society”, “economy”, “nation”, “globalization” or “tradition” (35). More specifically, in the field of hydraulics, action taken by the US Bureau of Reclamation (BR) on the Mekong River in the 1960s can be seen as a key element of the US government strategy during the Cold war to counter Soviet and Chinese influence in South-East Asia and as a way for the BR and the Tennessee Valley Authority to deploy water management models abroad while encountering difficulties at home (36).

Circulation processes

Once produced, knowledge about the environment continues to be transformed as it circulates and is implemented (37). Colonial centers of power projected discourses and management practices on the territories they conquered (38). Centers of power acted in a similar manner toward the periphery on their national territory. The transformation of water management in southwestern France (39), or in Spain (41) and the USA (40) can be understood as a form of internal colonization. If we take the example of France, water-related technical elites, knowledge and practices also circulated between France and its remote territories via colonization. These returned to their country of origin but only after being transformed through their implementation and local appropriation in colonized lands. For instance, the partitioning of land into small irrigated plots, first developed in Indochina, was promoted after 1950 in both France and Vietnam by the *Compagnie Nationale d'Aménagement du Bas-Rhône et du Languedoc* (BRL) (41). This circulation back and forth challenges the idea of impermeable boundaries separating a center from its periphery or of unidirectional relations between the two. At best, such boundaries are necessarily porous (42).

Naturalizing political choices

Technology is often regarded as apolitical even though various scholars have demonstrated the opposite. As one of many examples in the literature, D. Mosse (43) shows how power relations and rulers' political interests have shaped the design of the entire hydraulic infrastructure inscribed in the

South Indian landscape since medieval times: layout of drainage networks, as well as damming and diversion of rivers, interlinking of semi-embanked seasonal lakes, or repositioning of channels. For centuries hydrology has thus been politically manipulated whereas water control has actively contributed to the making of social and political institutions.

Advanced scientific discourses also generally appear to be apolitical when representing practices and scales of analysis as if they were natural and inevitable, as illustrated above with the example of watersheds. The numerous political choices made when developing these discourses have often been smoothed out. We consider that they deserve further analysis to open avenues for imagining broader and more pluralistic futures. For example, quantitative indicators are increasingly used to design and implement water policies. They systematically embed compromises between negotiated norms and scientific claims. For instance, determining the concentrations of pollutants, such as PCBs (polychlorinated biphenyls) that can be tolerated in wastewater released into a river, involves significant political compromises (44). And when determining minimum flow requirements, actors such as public agencies, users' committees or electricity suppliers may naturalize some water needs and quell uncertainties to better control waterscapes (45). The definition of thresholds that both qualify and govern water shortage implies significant compromises between irrigators' and State representatives, even though scientific discourses may be used only a posteriori to legitimize the figures chosen (46,47). Various scholars have demonstrated that water scarcity does not only result from biophysical constraints. During the British mandate of Palestine, for instance, Zionist hydrologists estimated that the region had abundant water resources but once the State of Israel had been created they announced a scarcity based on the same data (48). The very idea of "water crisis" is necessarily a compromise between political expectations and scientific measurements (49).

Hydrological modeling usually silences any conflict over the political environmental agenda and territorial claims while developing indicators that match specific problems and areas of responsibility. It portrays systems as separate from any social or historical fabric while achieving significant political work (50). This was the case, for example, in the La Ligua river basin in Chile where the State administration used water balance modeling to demonstrate transparency, while allowing little if any scrutiny in a context where it struggled to establish its authority. The State administration used modeling to govern uncertainties concerning water flows politically, while claiming that it was a "pure" physical and technical assessment meant to define an objective solution to groundwater overexploitation. This contributed to obscuring the underlying sociopolitical processes configuring the waterscape, such as asymmetries between commercial and peasant farmers, while ignoring the fact that they do not have the same capacities to negotiate and submit water rights applications or the same implication in the problematic groundwater dynamics that first justified the assessment (51). Ignoring such social, political and historical processes or disregarding forms of knowledge that are not necessarily compatible with water balance framings partly results from the secondary role reserved for social scientists in large-scale water research projects, in which they most often only contribute marginally to the production of theoretical and methodological frameworks (52).

Controversies over expertise: knowledge as a tool for broader political conflicts

STS have long demonstrated the way in which controversy over scientific facts and technology reveals broader political conflicts. Models, indicators and other commensuration processes dominate the water realm. However, only a few scholars of water studies have highlighted the political struggles

that underlie such processes (26,53). Knowledge acts as a means of producing new rights which few historians working on water have discussed. Prospective irrigators seeking to acquire water rights may promote representations of water scarcity to suit their own plans. This happened in nineteenth-century southeastern France, for instance, where controversies over water scarcity were associated with struggles between existing water-right holders and those claiming to hold new rights (54). In the late eighteenth-century, controversies surrounding the definition of Paris's water needs opposed two types of engineers trained in a different way and with a different ethos. On the one hand, French State engineers from the Ponts et Chaussées, who until the Revolution were not in charge of water issues, contended that water needs could be assessed objectively and scientifically thanks to measuring devices that they saw as instruments capable of producing unquestionable facts. This could be done regardless of any value judgments or political intentions concerning these "needs" and their trends. On the other hand, practically trained engineers-cum-water specialists argued that water consumption might increase if more water were available. For them, the needs inevitably depended on political intentions, norms and ideals. Nevertheless, State engineers ultimately achieved autonomy and power over technical decisions (55). Today controversies also oppose different forms of expertise produced or mobilized by States, local governments, private companies, NGOs, "local communities", etc. They can involve knowledge of a different or same type. In Peru for instance, both 'scientific' and 'local' knowledge was mobilized by the actors opposing and promoting the development of gold mines (56).

NEW LINES OF RESEARCH

We seek to shed more light on the production of categories and on boundary making regarding water representation and governance. Boundary making is the process through which nature and society but also science and non-science are separated; it also defines who is legitimate to speak on behalf of each of the defined categories, and in this process, scientists and experts play a key political role (57). To move ahead, we propose a few concepts, approaches and analytical frameworks. First, the multi-scalar social and political dynamics of water use and access have to be understood with scale as a constructed variable. Second, the concepts of legal pluralism and water tenure also help to understand the heterogeneity of rules and practices governing water use and access. Third, as historical accounts suggest, we need to focus on the contingency factors involved in explaining changes in water-governing regimes, as well as on the political context that influences paradigm trajectories. Fourth, concepts that help to understand material water flows and their related social and political dimensions are essential when carrying out an empirical study.

Grasping the multi-scalar dimensions of water use and access

Scholars studying common-pool resources have emphasized how the access to and the use of local resources evolve according to diverse factors, such as demographic changes, market penetration, State policies and technological innovations (58). Political ecologists focus on the multi-scalar dimensions of environmental discourses and practices (59). For instance, when farmers start preferring individual tube wells which pump groundwater to collective irrigation canals that draw water from rivers or dams, this modifies profoundly the scales over which people's mutual relationships to water will extend. These local practices also have to be understood as the result of broader political and economic dynamics that enable them to exist. Similarly, local changes in the spatial organization of water irrigation management in Nepal are partly a consequence of national

policies and of international institution guidelines that promote water users associations; social composition and territorial delimitations of the latter may indeed reconfigure previous ones (60). Localized change in the use of water tends to have unexpected consequences elsewhere or at the expense of others, such as in the case of “basin closure” (61). The scales of water access and management are thus the product of heterogeneous, complex dimensions (of a technical, institutional, economic or another nature) that require close scrutiny.

Water research would benefit from harnessing research that studies scales not as a given but as social productions (62) (63). We need to consider scales as relational, contingent and systematically contested by those who articulate their strategies or representations differently (64). Investigating the construction of scales in water studies allows us to understand the processes that define categories as “local” and “global”. To overcome such dualisms is necessary if we are to better understand underlying power relations (65). Defining scale implies processes of including and excluding people (66). Promoting a larger scale may be a way of concealing local conflicts (67) or making some patterns or relationships invisible, as certain processes can only be grasped on a specific scale (62)

Analyzing water tenure in reality

For decades research based on field work has suggested that the way in which societies define and grant water rights is of a plural nature. Scholars have shown that different normative orders, i.e. legal pluralism, work and interact in a given society (68). Legal pluralism applies particularly well to water since the latter is usually governed by heterogeneous rules, norms and regulations that might or might not be state-driven and which are never set in stone (69). When users mobilize their forces and fight for the State to recognize their water rights they generally want the diversity of their bundle of rights regarding access to, withdrawal, management and control of water and of water users to be acknowledged first (70). Property titles are rarely the dominant access modality to water. In property theory, “access” is usually inadequately defined. Ribot and Peluso (71) instead propose a broader and powerful definition of access as the ability to derive benefits from things and not only the right to benefit from things. Access is understood as a bundle of power included in a wide range of social relationships that affect people’s ability to gain, control and maintain access to resources.

One way of delving deeper into this water-related complexity is to adopt the concept of “water tenure”. Water tenure represents the relationship, whether defined legally or customarily, *between people* with respect to water rather than a relationship between the “user” and “water” (72). Tenure arrangements are what determine how people, communities and organizations gain access to and make use of natural resources. Applying this concept to water may help understand unstable relations, such as those based on an annual contract or chaotic water use, such as when too many sources of rules compete and clash with each other (*Ibid.*). To identify water tenure, field-based and inductive oriented research is encouraged to grasp the diversity of “arrangements”, to understand whether water rights are secure and which factors indicate how secure or insecure they are. Water tenure therefore not only involves legal pluralism but also the analysis of any types of contract (related to water, land or labor) or any type of device that allows or constrains water access.

Taking into account temporalities and politics

Historians of science have effectively demonstrated how grasping social and political contexts is key

to understanding the success or failure of paradigms. Locher (73,74), for instance, recently analyzed the trajectory of the “commons” paradigm. In the 1970s this emerged from the crisis surrounding the US “development project” to “modernize” Third World countries based on large-scale State intervention that had also been fertile ground for Hardin’s tragedy of the commons. Community-based governance became the new solution to be promoted within public development aid schemes. This move also provided visibility and financial means to a new generation of scholars who fashioned an important and diverse academic movement.

The analysis of past and recent trajectories of interactions between water and society suggests that they associate intentionality, forms of determinisms and unplanned, unforeseen events, actions, i.e. contingency. The way scholars identify intentionality and contingency is most often explained by their analytical framework (20). This can be illustrated in the different and somehow complementary way Camprubi (75) and Swyngedouw (76) analyze the co-production of techno-scientific, political and natural orders during Franco’s regime in Spain. Camprubi studies how elite networks of non-military engineers shaped the economic structure and ideological outlook of the authoritarian regime and also transformed the social and technical environment of peasants, workers, housewives, and manufacturers. His emphasis lies on contingencies. Swyngedouw, instead, provides a more global picture of the way nature was harnessed for a series of Spanish political projects, which mainly depicts Spanish hydropolitics and its main paradigms as the product of Spanish modern State intentionality.

Analyzing both political and material dimensions of water

Approaches that fully address the material configuration of things can be of great use in analyzing water issues.

The term “paracommons” refers to the aggregated material gains potentially generated by improvements to the efficiency of several systems, such as the irrigation systems of a set of farmers, for instance, all drawing water from the same source (77). Addressing water through the lens of the paracommons opens new avenues for studying the links between knowledge, technology and power. It enables us to consider water as a flow, part of which is channeled into a trajectory that is deemed useful, such as the part of the flow that is evapotranspired by the plants the farmer plans to cultivate. The rest of the flow is divided into a variety of trajectories that are designated as “waste” since they do not meet the idea of the “efficient” use of water promoted by the dominant point of view. These trajectories may direct water into a neighbors’ field, to the neighboring village’s well or to wild plants that ensure food security for the poor. This water is clearly not wasted for everyone. The concept of the paracommons shows that improving the efficiency of one system means channeling more water into a trajectory deemed useful, thereby automatically reducing the flow into trajectories that are labelled “waste” by those who define efficiency. Waste for one system constitutes a gain for other users, whether human or non-human. A paracommons-based approach sheds light on these users and on the way they are dispossessed of water for the sake of improving efficiency. The concept of paracommons opens up both theoretical and practical lines of research. It allows us to identify power relations embedded in the outwardly neutral concept of efficiency. The detailed study of the various trajectories water follows, from the point it is abstracted to the point it evapotranspires or evaporates, allows a practical understanding of dispossession when any water development project is undertaken. Such a concept helps to explore the way the notion of efficiency acts as an interpretive scheme embedded in a structure of signification that supports a specific structure of domination.

When studying petrol, T. Mitchell (78) also gives serious consideration to the political dimension of ecological materiality. He shows that the material conditions of political regimes are key to understanding their social construction. He follows the resource, i.e. carbon flows, to grasp how it is "hybridized" with distinct forms of power. For instance, the weight of coal in the economy gave miners the power to interrupt the flows that fed the economy. Although their claims had always been severely repressed, by the end of the nineteenth century massive strikes had contributed to the advent of forms of social concessions with the setting up of syndicates, the expansion of universal suffrage or the adoption of social insurance laws in Europe. The advent of oil then became a means of avoiding workers' movements: oil is much more capital- than labor-intensive, its extraction is easier to control, and its refining requires more varied categories of workers and a greater diversity of skills that call upon and favor engineers. Contrary to oil, water flows do not shape the world economy; and generating rents from water has not meant controlling its circulation over very long distances or shaping and controlling the international monetary system. Water, in its liquid state, only circulates locally. However, the profits from the water realm are produced by a whole range of actors and circulate extensively through complex paths that need to be understood better. This includes profits made not only through what is produced with water but also indirectly thanks to all the technology, knowledge and devices used to withdraw, treat or make water available. Here materiality concerns are not limited to water materiality or technology, and water problems do not only concern water.

Conclusion

This review proposes a broad perspective of the literature that addresses the relations between power, water knowledge and technology. Technologies and forms of knowledge are ontologically inseparable from the politics they enact or facilitate even though actors strive to represent them as objective and neutral facts, often to help render them hegemonic and facilitate their circulation. These processes reshape society fundamentally: they may reinforce or overturn social asymmetries. To find out which direction this may take, field research is crucial. Lastly, it is also important to bear in mind that cultivating the unknown and the unintelligible may also boost social or political power.

We have suggested four paths to further explore the relations between power, water technology and knowledge. One should never consider scale as a given, but should use the analytical tools available to address its political construction. In doing this, special attention could be given to the way in which "contexts" and paradigms are historically shaped. Field work based research also needs to further explore the diversity and dynamics of the relationships between people with respect to the way they gain access to and use water, as well as the complexity of water materiality and of its interactions with social organizations.

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