Connected and disrupted hydrosocial territories: the making of modern socionatures through inter-basin water transfers

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Abstract

Actual and projected water scarcity has accelerated the scale of hydrological infrastructure and the number of Inter-Basin Water Transfers (IBWTs), which move freshwater from one geographically distinct river catchment or basin to another. IBWTs are supply-side programs that pose distinct water governance challenges. If all projected IBWTs are completed by 2050, the volume of water transferred would be 48% of global water withdrawals. This article examines IBWTs from a socionatural perspective. Building on the political ecology scholarship of hydrosocial territories, I probe how IWBTs co-constitute and reconfigure socionatural relations, and how these are experienced by communities and ecologies in unequal ways. I discuss how IBWTs bring about changes, what features of hydrosocial territories they influence, and what conflicts emerge. For 29 IBWTs I define their multiple socionatural dimensions – biophysical, socioeconomic and governance – and the interrelations between them. IBWTs generally degrade biophysical and socioeconomic conditions for communities in water-sending "donor" basins, and condition future territorial reconfigurations. Water governance institutions are ill-equipped to take on the challenge that IBWTs bring in governing across multiple basins, indicated by the conflicts they generate. These concern defense of territory and ways of life, as well as allocation disputes. Political conflicts emerge because worlds shift irrevocably when IBWTs become fixtures of hydrosocial territories.

Key words: Socionatures, political ecology, human-environment relations, socionatural regimes, hydrological infrastructure, hydrosocial territories

Résumé

La pénurie d'eau actuelle et prévue a accéléré le développement en nombre et en échelle de l'infrastructure hydrologique sous la forme de transferts d'eau entre bassins (IBWT), qui déplacent l'eau douce d'un bassin hydrographique géographiquement distinct à un autre. Les transferts d'eau entre bassins sont des politiques de l'offre qui posent des défis distincts en matière de gouvernance de l'eau. Si tous les IBWT prévus sont réalisés d'ici 2050, le volume d'eau transféré représenterait 48 % des prélèvements d'eau dans le monde. Cet article examine les IBWT d'un point de vue socionaturel. S'appuyant sur les travaux d'écologie politique sur les territoires hydrosociaux, j'étudie la manière dont les IBWT co-constituent et reconfigurent les relations socionaturelles, et comment celles-ci sont vécues de manière inégale par les communautés et les écologies. Je discute de la manière dont les IBWT apportent des changements, des caractéristiques des territoires hydrosociaux qu'elles influencent et des conflits qui en découlent. Pour 29 IBWT, je définis leurs multiples dimensions socio-naturelles - biophysiques, socio-économiques et de gouvernance - et les interrelations entre elles. Les IBWT dégradent généralement les conditions biophysiques et socio-économiques des communautés dans les bassins "donneurs" d'eau et conditionnent les reconfigurations territoriales futures. Les institutions de

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gouvernance de l'eau sont mal équipées pour relever le défi que représentent les IBWT dans la gouvernance de plusieurs bassins, comme en témoignent les conflits qu'ils génèrent. Ceux-ci concernent la défense du territoire et des modes de vie, ainsi que les conflits de répartition. Les conflits politiques émergent parce que les mondes changent irrévocablement lorsque les IBWT deviennent des éléments fixes des territoires hydrosociaux.

Mots clés: Socionatures, "political ecology", relations homme-environnement, régimes socionaturels, infrastructures hydrologiques, territoires hydrosociaux

Resumen

La escasez hídrica actual y proyectada ha acelerado el desarrollo en escala como en número de los Trasvases de Agua entre Cuencas (TAC). Estas obras son excepcionales porque transfieren agua fresca desde una cuenca particular a otra. Los TAC representan la continuación de las políticas hídricas de oferta y presentan desafíos particulares para la gobernanza del agua. Esto es importante: si todas los TAC proyectadas para el 2050 terminan por completarse, el volumen de agua transferida representaría un 48% del agua fresca extraída a nivel mundial. Este artículo examina los TAC desde una perspectiva socionatural. Construyendo sobre los estudios de la ecología política de los territorios hidrosociales, examino como los TAC constituyen conjuntamente y reconfiguran las relaciones socionaturales, y complemento elementos discursivos del concepto del territorio hidrosocial con el del concepto de regímenes socionaturales para entender como los cambios causados por los TAC son vividas por comunidades y ecologías de formas desiguales. Esto requiere ver como los TAC causan cambios sociales y ecológicos en los territorios hidrosociales, que características de los territorios hidrosociales son influenciadas por los TAC, como estos cambios informan el concepto de los territorios hidrosociales, y que consecuencias hay para entender los cuestionamientos. A través de un estudio ilustrativo de 26 artículos y capítulos científicos, identifico las varias dimensiones socionaturales – la biofísica, la socioeconómica, y la gobernanza – y sus interrelaciones en cada uno de las 29 TAC descritas en esta literatura. A partir de este estudio, descubrí que los TAC, por lo general, causan una degradación de la dimensión biofísica y de las condiciones socioeconómicas de las comunidades en las cuencas 'donantes' de agua, y que los TAC pueden ser potencialmente duraderos en el tiempo y que condiciona las futuras reconfiguraciones territoriales. El número de cuestionamientos también sugiere que las instituciones que gobiernan el agua carecen de la capacidad para afrontar los desafíos que conllevan los TAC para gobernar varias cuencas conjuntamente. Asimismo, los TAC generan cuestionamientos que van más allá de una simple disputa de asignación de cuantía de agua y que llegan a ser disputas en torno a la defensa de un territorio y de modos de vida. Los cuestionamientos, vistas desde una perspectiva socionatural, resaltan los intereses y precios políticos para aquellos que observan sus mundos cambiar irrevocablemente cuando un TAC entra a formar parte de su paisaje hídrico.

Palabras clave: Socionaturalezas, Ecología política, Relaciones humano-ambiente, Régimenes socionaturales, Infraestructuras hidrológicas, Territorios hidrosociales

1. Introduction

Actual and projected water scarcity has accelerated the development, in number and in scale, of hydrological infrastructure, particularly of mega-projects in the form of Inter-Basin Water Transfers (IBWTs). IBWTs transfer freshwater from one "geographically distinct river catchment or basin to another" (Davies *et al*., 1992, p. 327). In the most ambitious cases, multi-IBWT hydro-networks are planned, such as India's river linking program or China's South to North Water Transfer. Water governance paradigms shift towards Integrated Water Resource Management (IWRM) in the 1990s, supporting equity, ecological integrity and economic efficiency. But IBWTs are increasing in number (Gupta & van der Zaag, 2008). If all projected IBWTs are completed by 2050, the volume of water transferred would be 48% of global water withdrawal (Shumilova *et al*., 2018). This matters since transformations wrought by IBWTs are multi-scalar, multi-dimensional and multi-basin, affecting ecologies, societies, and water governance politics and institutions in highly unequal, inter-related and contentious ways.

Complex, multi-scalar, and multi-territorial, IBWTs provide opportunities to develop interdisciplinary political ecology scholarship on socionatural perspectives. Political ecologies of water have emerged, exploring socionatures as assemblages, notably through waterscapes (Swyngedouw, 1999, 2015b) and more recently through the hydrosocial cycle (Linton & Budds, 2014) and hydrosocial territories (Boelens *et al*., 2016). An emerging political ecology of water transfers, posits IBWTs as archetypally socionatural and embodying the materialization of the contested imaginaries of hydrosocial territories (Bourblanc & Blanchon, 2014; Hommes & Boelens, 2017; Islar & Boda, 2014). A main focus has been on higher scale processes and authority, when socionatural transformations occur locally. Features of change to socionatures is only briefly described or mapped. Finally, the question of a hydrological intervention's temporality and how it influences contested imaginaries of territories is yet to be explored.

I argue that this emerging field can be developed by incorporating the concept of socionatural regimes (Kolinjivadi *et al*., 2020) into a critical review of IBWT cases in the scientific literature. While building on insights from previous reviews of IBWTs (Gupta & van der Zaag, 2008; Purvis & Dinar, 2020; J.-D. Rinaudo & Barraqué, 2015; Shumilova *et al*., 2018), I analyze the socionatural dimensions of the hydrosocial territories that IBWTs co-constitute, focusing on biophysical and socioeconomic relationships that give rise to changing political directions and contested imaginaries. I also examine the ways modern socionatural regimes shape perceptions of water through IBWTs, and how they fit in an understanding of hydrosocial territories. Three questions guiding this article are: How have IBWTs brought about social and ecological changes to hydrosocial territories? Do IBTSs always serve modern socionatural regimes, and what consequences are there for understanding contestations linked to IBWTs? Reviewing IBWT cases from twelve years of scientific literature, I aim to showcase IBWTs' socionatural transformations and the responses and resistances to these as examples of the emergent tensions of locally situated struggles to create more just, equitable, and ecologically robust hydrosocial territories.

Section Two introduces IBWTs as multidisciplinary problems best understood 'socionaturally.' It presents the socionatural concepts developed in the political ecology of water, establishing hydrosocial territories as particularly useful to examine IBWTs through its use of contested imaginaries. Identifying gaps in this literature, I present socionatural regimes (Escobar, 1999; Kolinjivadi *et al*., 2020) as a complementary socionatural concept that can support the understanding of IBWT changes from a hydrosocial territorial lens. The following Section presents the critical literature review, taking heed to make it explicitly qualitative and narrative to best understand the linkages across socionatural dimensions and how contestations emerge. Section Four collects four pertinent issues emerging from the literature and critical literature review, exploring 1) how IBWTs degrade socionatural dimensions, 2) how these dimensions are inseparable, 3) a presentation of the long duration and changing water uses of IBWTs, and 4) contested IBWT territories. Before concluding, I discuss how IBWTs are the realization of specific imaginaries that bring about socionatural disintegrity, and that as a form of major infrastructure they fashion new territories. They continue the standardizing and rationalizing tenets of modern socionatural regimes. Resistance and contestation defends socionatural territories, rejecting state and capital-led visions of water use, but an absence of contestation also reflects state-subject making as well as differing understandings of where authority, and visions supporting it, emanate from.

2. Theory and conceptual framework

Interbasin Water Transfer

IBWTs transfer water from river basins where it is considered in excess, to basins where it is considered scarce. Yet IBWTs are difficult to typologize: they can transfer water amongst sub-basins within a single river basin as intra-basin water transfers, or cross 'transfer' basins found between a donor and recipient basin (Figure 1). Within water management literature, IBWTs are a supply-side water management option. These supply-side options aim to increase water supply, though it is not always as a response to increased water demand. Increasing water supply in specific places, whether through IBWTs, dams, desalination plants, navigation schemes or groundwater pumping, sets conditions to trigger economic and social development but is also an expression of national and political power (Shumilova *et al*., 2018; Sternberg, 2015).

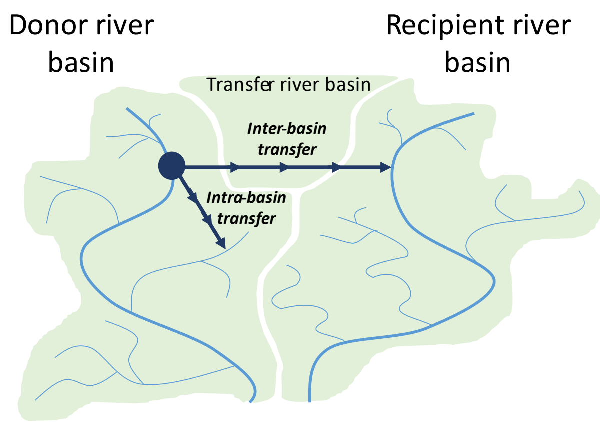

Figure 1: Illustration of donor and recipient basins within Inter- and Intra-Basin Water Transfers. Source: Author's own illustration.

IBWTs share common features with other types of hydrological infrastructure, y*et also* stand apart. They can be multi-purpose and large-scale, and require substantial investments in infrastructure and storage, and exist to support economic activities (Gupta & van der Zaag, 2008; Purvis & Dinar, 2020). IBWTs are also unique in that they are assemblages of hydrological infrastructure that connect previously unconnected river basins. This means there are single elements of the hydrological infrastructure that makes up an IBWT, such as dams, but also an increase in the spatial scale at which water is managed. Understanding IBWTs is best tackled in a transdisciplinary manner (Gupta & van der Zaag, 2008). By working with and justifying concepts of water surplus and scarcity, or the river basin as the preferred management unit, these concepts become naturalized and unquestioned within scientific and public discourse.

As they increase in number, scope and scale, IBWTs raise a gamut of issues: flow disruptions, contamination, introduction of non-native species, and political conflict. The latter can be between communities across donor, transmitting and recipient river basins, as well as between rural and urban inhabitants. Water governance literature has examined a number of topics concerning IBWTs: their alignment with tenets of Integrated Water Resource Management or IWRM (Gupta & van der Zaag, 2008); their historical and current evolution and popularity as an engineering intervention (J.-D. Rinaudo & Barraqué, 2015); their importance within the water-food-energy nexus (Shumilova *et al*., 2018); and their sustainability as a policy intervention (Purvis & Dinar, 2020). Two features of IBWTs emerge from these discussions. The first is scale. IBWTs increase complexity by increasing the territory and the number of connected water users (Gupta & van der Zaag, 2008), and IBWT-induced environmental impacts occur at larger scales, including salinization and the loss of habitats (Shumilova *et al*., 2018). Second, all agree on the mixed bag of advantages and disadvantages IBWTs bring about. Purvis & Dinar (2020) found that environmental management and environmental rehabilitation outcomes had positive results, but that environmental effects, irrigation outcomes, and environmental justice outcomes were likely to have negative results.

It is clear that IBWTs are increasing both in number and scope, with potentially long-lasting consequences. Analyses of IBWTs reveal questions focusing on their scale, dimensions, complexities and contradictions. Their complex, multi-dimensional impacts have been explored from governance perspectives, but an important issue not covered in this literature has been how IBWTs have been supported, resisted, and contested. To deal with this I employ a socionatural political ecology perspective.

The emerging political ecology of water transfers

Socionatural thinking emerges from political ecology scholarship on human-environment relations. It questions both the society-nature binary and established narratives and knowledge of the world, through critical analysis of the distribution of power, its application on the natural environment, and the unevenly distributed costs and benefits of environmental change (Loftus, 2009; Rocheleau & Roth, 2007). Political ecologies of water have been at the forefront of socionatural thinking. Political ecologists argue that water is part-natural, part-social, and socionatural water is seen as a process in which social relations are embedded (Bourblanc & Blanchon, 2014); that is, where power relations shape human knowledge of and intervention in water, leading to particular forms of governing nature and people (Boelens, 2015).

Political ecologies of water involve innovative concepts based on socionatural thinking. These engage with socioenvironmental injustices stemming from the complex interaction of nature, society, technology and culture (Bourblanc & Blanchon, 2014; Truelove, 2011; Zwarteveen & Boelens, 2014). Political ecologies of water are hybrid styles that combine material and discursive analyses (Rodríguez-Labajos & Martínez-Alier, 2015) exploring the coproduction of socionatural assemblages. The concept of "waterscapes" (see Swyngedouw, 1999, 2015b), was an initial effort in this direction, and inspired further complementary conceptual thinking. Waterscapes became more nuanced, for example by putting gender and constitutive power relations in relation to contaminated water (Sultana, 2011) or analyzing everyday dimensions of resource inequality through processes of social and spatial differentiation (Truelove, 2011).

IBWTs have recently been deployed to explore hydro-socionatural concepts, such as the hydrosocial cycle (Linton & Budds, 2014) and hydrosocial territories (Boelens *et al*., 2016), contributing to an emerging political ecology of water transfers. The hydrosocial cycle is explored by Bourblanc & Blanchon (2014) and Islar & Boda (2014), providing some important considerations: natural and artificial flows become part of the same hydrosocial cycle and exemplify socionature; water governance challenges are better understood through the cycle rather than through the basin; and the cycle also represents flows of social relations influencing investment strategies and structuring social relations themselves.

The concept of hydrosocial territories provides a strong conceptual grounding for understanding the socionature of IBWTs. It focuses on territories as contested imaginaries and their materializations, and "as a battle of divergent (dominant and non-dominant) discourses or narratives, [hydrosocial territoriality] has consolidating a particular order of things as its central stake" (Boelens *et al*., 2016, p. 7). Boelens *et al*. (2016) build their understanding of imaginaries on three characteristics. First, using Foucauldian governmentality as a concept to understand dominance. Second, they identify processes of subjectification and how they change. Finally, they recognize a plurality of scales, the idea of overlapping and contested 'territories within territory.'

While relatively new, hydrosocial territory literature has expanded quickly and is exploring the role of infrastructure in territorialization, conceptually and empirically. Hommes & Boelens's (2017) work on rural-urban relations in Peru builds on Boelens *et al*.'s initial definition of the concept of territory as a contested imaginary, and of 'territories within territory' (see Boelens *et al*. 2016, 2). Hommes & Boelens use 'contested imaginaries' to describe divergent interest groups' interpretations of current arrangements, and how the future should be. There are struggles over meanings in socionatural world views, how problems are defined, and over the material realization of imaginaries. Infrastructure is not just physical in form, but is accompanied by ascribed social norms, practices, networks and ideas with associated political interests and discourses. IBWTs are 'modern' phenomena, resulting in tense conflictual relationships between modernity's imaginary and its social, economic, and ecological costs. Mapping hydrosocial territorial changes instigated by IBWTs was conducted by Lopez *et al*. (2019) in Bolivia. The authors found shifting alliances across user groups who hold divergent imaginaries of what hydrosocial arrangements should be, engaging various stakeholders at different scales of administration and (global) finance.

This emerging political ecology of water transfers builds on a strong tradition of socionatural thinking. Bourblanc & Blanchon's (2014) use of the hydrosocial cycle concept to critique the assumption that the river basin is the natural unit for water governance is part of a tradition of calling out naturalizing discourses in water governance that underpin socioenvironmental injustices (Molle, 2009; Swyngedouw, 2015; Zwarteveen & Boelens, 2014). This tradition also critiques a lack of political analysis in scholarship on human-environment relations and socio-ecological systems (Cote & Nightingale, 2012), and questions the naturalization of institutional immobility. Islar & Boda's (2014) analysis of problem-framing speaks to the relationship between expert knowledge and power, where scarcity of water is naturalized to justify IBWT interventions. Urban areas are also identified as predatory, appropriating water from rural areas, an instigating socionatural changes leading to increased inequality. Hommes & Boelens (2017) argue that the collision of unequal imaginaries in the constitution of new hydrosocial territories involves the materialization of their discourses and vision, realized through the mobilization of power.

Several gaps appear in the literature on water governance and the political ecology of water. They suggest the flow of power across scales is generally in one direction, downward. Yet hydraulic vision and decision-making can spill upwards to higher scales of authority, and to political and financial power. More particularly, we see that IBWTs create new hydrosocial territories, but little attention has been paid to what social or environmental features of these territories and socionatural systems are altered, how this happens, along what imaginaries, and by what means. Additionally, while the spatiality and multiple scales of IBWTs have been studied, their temporality – their longevity and what impact this duration has on imaginaries, other hydrological interventions, or policies – has not been sufficiently explored. A socionatural regime approach (Büscher *et al*., 2012; Escobar, 1999; Kolinjivadi *et al*., 2020) can provide a supplemental analysis of IBWT longevity that strengthens the use of a hydrosocial territorial analytical framework.

IBWTs and hydrosocial territories: territories, regimes, time and power

IBWTs can represent the insertion in time and space of assemblages that condition a particular type of material and discursive behavior, creating and engulfing territories along rearticulations of socionatural relations. This conditioning, however, is political. Following Escobar (1999), Kolinjivadi *et al*. define socionatural regimes as a set constellation of relational networks between humans and nature, representing "multi-scalar relational networks that both influence and are equally affected by a *tendency* towards ontological uniformity of socionature relations" (2020, p. 5, emphasis in original). They argue that *modern* socionatural regimes fix rigid, totalizing perceptions of time – informed by modern science in its standardization of reality and (non) human subjects – that are inherent to capital's socionatural relations. IBWTs as assemblages are manifestations of modern regimes, seen through increasing control over water (Hommes & Boelens, 2018), its rhythms, and a naturalization of its availability to where it is transferred.

IBWTs forming part of hydrosocial territories co-constitute state-society relations and modern socionatural regimes through the process of subjectification of humans and non-humans, particularly through the suppression of the divergent imaginaries that socionatural relations *could* have. Here, a feminist performative understanding of power provides a way to think with this issue. States do not just have power; rather, the exercise of power produces "stateness" and subjects, and the State as process shows "how the state emerges as a multi-sited, contradictory, and inconsistent set of effects" (Nightingale, 2018, p. 693). State subjectification effects are partial, renegotiating state-society boundaries of who or what belongs. As part of hydrosocial territorial imaginaries, planning and operation of IBWTs erases divergent histories, temporalities and futures of alternative water arrangements, thus serving the narrative and materialization of modern socionatural regimes. Feminist performative understandings of the State also give explanatory power over the appeal of IBWTs as development projects espoused by state and powerful actors, the contestation of IBWTs by other actors, or to what extent contestations shift the terms and legitimacy of state-building processes.

The idea of socionatural regimes helps us think about some of the gaps identified in hydrosocial territory literature, but when used to explore IBWTs and other hydrological infrastructure, it also informs associated environmental justice debates. Within the political ecology of water, Zwarteveen & Boelens (2014) include socio-natural justice (or socio-natural integrity) as an additional dimension to Schlosberg's three dimensions of environmental justice – distribution, recognition and participation (Schlosberg, 2004). Socio-ecological integrity stands apart from the previous dimensions because it recognizes three specific aspects: water's dual life-securing and life-threatening nature, its embeddedness in delicate and dynamically shaped socio-natural environments, and its role in inter-generational justice (Zwarteveen & Boelens, 2014, p. 147). The shift to thinking of justice in generational time opens ontological possibilities that include the plurality of generations of multiple species, and moves away from its uniformization. In a nutshell, thinking with IBWTs about how and why changes occur in hydrosocial territories, what regimes are constituted, and by which actors, leads us back to questions of the imperfect and constant co-constitution of hydrosocial territories, the resistance to these, and the durability and integrity of divergent territories.

I trace IBWTs and the changes they induce across different dimensions, and how they are experienced by communities and territories in unequal ways. Seeing how IBWTs impact different communities and processes requires understanding their multiple but deeply interlinked social and ecological dimensions (Rocheleau & Nirmal, 2015). To contribute to the emerging literature on hydrosocial territories and IBWTs, the principal aim is to examine how the scientific literature has documented how IBWTs change hydrosocial territories. Emerging from this, are the following sub-questions: How have IBWTs brought about social and ecological changes to hydrosocial territories? What features of hydrosocial territories are influenced by IBWTs? How do these changes conceptually inform hydrosocial territories and socionatural regimes? And what consequences are there for understanding contestations linked to IBWTs?

2. Methodology

This article reviews how the scientific literature has documented biophysical, socioeconomic and water governance changes where IBWTs are planned or initiated. Historically, the aim of reviews of this nature is to synthesize knowledge for the generation of "best" evidence and filtering out "bad" evidence to be used by decision-makers (Grant & Booth, 2009), and arrive "at working research conclusions and workable practice solutions" (Sandelowski, 2008, p. 104). Reviews as methodology have been critiqued particularly when positioned as an objective approach to summarize research. Systematic reviews tend to favor quantitative research over other ways of knowing (Pope, 2003); knowledge systematization and procedural objectivity claims may suppress quality (Maclure, 2005); and highly contextual fields present challenges about suitability for knowledge synthesis (Chambers *et al*., 2018). Taking these critiques into consideration, review methodologies can still be "a critically useful interpretation and unpacking of a problematic that situates the work historically and methodologically" (Lather, 1999, p. 3).

Reviews of IBWTs present challenges. In the most recent review of IBWTs, Purvis & Dinar (2020, p. 4) note that literature on IBWTs is too inconsistent to develop their own empirical methodology. Similarly, the multiplicity of approaches and disciplines that examined IBWTs makes attempts at a systematic, quantifiable review inappropriate. For these reasons I present a more qualitative account of IBWT cases, illustrating different hydrosocial dimensions, changes in these, and interlinkages as described in the cases themselves.

The mapping and narrative process is inspired by network thinking. Rocheleau & Roth (2007, p. 433) encourage researchers "to apply network metaphors, models and theories to questions of power … integration of culture and nature, and relations of rootedness and mobility within and across territories." Networks help conceptualize the interlinkages of different dimensions and scale, focusing attention on interlinkages and reciprocal effects cascading across the network. To see how power is deployed, acted on and through whom, network approaches also ask to keep in mind communities' positions within networks, in terms of multiple dimensions, processes and scales, not only their geographical position.

Following a network approach, I used an iterative process to map and interpret these narratives, resulting in a narrative account of biophysical and socioeconomic conditions and changes caused by IBWTs, a deeper comparison of interlinked hydrosocial territories in four typologies, and an account of conflicts and contestations emerging from IBWTs. I identified dimensions and variables in the literature review on both IBWTs and the political ecology of water that provide interlinkages between and within dimensions across basins connected through IBWTs (Table 1). The review framework established three dimensions: biophysical, socioeconomic and water governance. Within each dimension, I established variables and classified them as 'descriptive' and 'outcome.' The former describes conditions prior to IBWT construction and operation. The latter describe changes or issues that are relevant once IBWTs are operating.

	Hydrosocial dimensions		
Variables	**Biophysical variables**	**Socioeconomic variables**	**Water governance variables**
	• Basins • Flow • Habitat • Species distribution • Contaminants	• Demography and habitation • Economic activities and agriculture and forestry • Other extractive industries • Water consumption	• Allocation • Monitoring • Institutions • Contestation

Table 1: Hydrosocial dimensions and their variables. Source: Author's own compilation

The sample was established by using the Scopus search engine. Search criteria were: "Interbasin transfer" or "inter-basin transfer" or "interbasin transfers" or "inter-basin transfers", for articles published since 1989. The result was 274 articles. This sample was explored with further exclusion and inclusion criteria. To capture social dimensions as well as some narrative description of all dimensions of IBWTs, the review excluded sources other than journal articles and book chapters, articles whose exclusive topics were in disciplines outside of the social sciences, and those where more than four IBWT cases are discussed. After further examination of articles published prior to 2011, these, aside from two articles, were not found to have enough information for the review exercise. The final sample was 26 articles and book chapters (see appendix 1). Some 29 IBWTs were identified in the sample. Out of these, 11 were sub-project IBWTs of 5 large-scale IBWT projects. This generated a total of 52 cases of IBWTs reviewed (see Appendix 2). At the time of publication of the articles, 26 IBWT cases had been built, another 21 were planned, two were halted and three were cancelled.

3. Results

This section presents the four most pertinent themes emerging from the review that inform what features of hydrosocial territories change as a result of IBWTs. These are:

1) the impacts caused by IBWTs as measured by variables (full descriptions of all variables covered in the review can be found in Appendix 3);
2) the interconnections across groups of impacts;
3) the longevity of IBWTs; and
4) the nature of contestations arising from IBWT planning and operation.

The section closes with a description of contestations emerging from IBWTs.

IBWT impacts

Whether looking within or across biophysical or socioeconomic dimensions, IBWTs seem to degrade variables. Socioeconomic variables negatively affect biophysical variables, and governance variables react slowly. IBWTs trigger declines in biophysical variables when these interplay in unequal ways with socioeconomic systems, particularly where economic and extractive activities are concerned. Flow affects certain economic activities as does water quality and its migration, but in specific places and territories, and certainly not where the benefits of an IBWT accrue.

Contamination emerged as the most common impact linked to IBWTs. Most contamination was found in water, with half of cases reporting these in recipient basins compared to slightly less than half in donor basins. Three IBWTs stand out: the Ankara Kizilirmak plan in Turkey (Islar & Boda, 2014, p. 4), the Lesotho Highland

Water Project (Blanchon, 2015, p. 168), and China's South to North Water Transfer (Rogers *et al*., 2020). These cases highlight the urgency with which IBWTs are planned in periods of drought, the extractive contexts for newer justifications of water transfers, the increasing government concern about contamination, and the unknown consequences of changing water flows for which they cannot plan.

Economic activities in donor basins also suffered due to IBWT operation. In four cases in China and Turkey, industries were forced to cease operation and communities were relocated to reduce polluting activities and maintain water quality for water transfer. Two other cases mention livestock damage through IBWT operation in recipient basins. In Nogales, Mexico, wastewater infiltration in the water table harmed livestock (Prichard & Scott, 2014). In South Africa's Orange River Development Project, the spread of pests in the recipient basin harmed livestock (Gupta & van der Zaag, 2008).

Finally, IBWTs bring about population movements caused by uncertainty for rural livelihoods, relocations, or opportunities in urban areas. Operational IBWTs aided urban areas to expand and attract in-migrants, surpassing the biophysical limitations of local water supplies. Population movements attributed to IBWTs occurred in Turkey, China, the USA and Mexico, nearly all occurring in donor basins. In Turkey, prolonged planning of the Istanbul Greater Melen project caused uncertainty for rural inhabitants, pushing them to migrate to urban areas (Islar & Boda, 2014). In China, construction of the whole South to North Water Transfer is expected to relocate 300,000 people (Gupta & van der Zaag, 2008).

Webs of interconnected IBWT impacts

IBWTs are multi-dimensional and multi-scalar, and when analyzing these with a socionatural perspective, this multiplicity can be mapped. In this section, I selected six cases and four IBWTs with different operating status (Figure 2). Following a short description of each case, I map and analyze causal links between each variable, noting where interconnections are described by authors as having a positive, negative, or undetermined effect.

The planned Integration Project of the Sao Francisco River in Brazil aims to transfer water from the Sao Francisco river basin to the semi-arid north east of Brazil for irrigation, urban residential, and industry needs. While plans have been proposed since the 19th century, there are concerns this IBWT will cause significant environmental problems by reducing water availability in the Sao Francisco basin, and that benefits will accrue to large landowners (de Andrade *et al*., 2011).

The temporary Jucar to Amadorio and Algar transfers in Spain occurred between 1999 and 2001, during extreme water scarcity in the Amadorio and Algar rivers. The donor Jucar river recovered from a drought period and its water was transferred to meet urban residential needs, since traditional aquifer sources were compromised. Envisaged to last 5 months, the transfer continued for two years (Sanchis-Ibor *et al*., 2019).

The cancelled Cutzamala system stage IV transfer in Mexico aimed to transfer water from the Temascaltepec river to the Valley of Mexico to supply Mexico City, as an expansion of an existing network of IBWTs. Despite initial construction, the project was cancelled following resistance from social movements comprised of inhabitants in the Temascaltepec river basin (Cabral & Ávila-García, 2013).

The completed Nogales interbasin transfer between Mexico and the USA is a two-way transfer between Mexico's Los Alisos river basin and the USA's Upper Santa Cruz river basin, with fresh water transferred from Los Alisos to Nogales in the Upper Santa Cruz basin, and wastewater transferred back to the Los Alisos basin for treatment, thereby avoiding expensive treatment in the USA. Wastewater return flow increased surface flow in Los Alisos, but caused groundwater contamination. Dry wells in rural areas persist, and wastewater continues to increase in urban areas (Prichard & Scott, 2014).

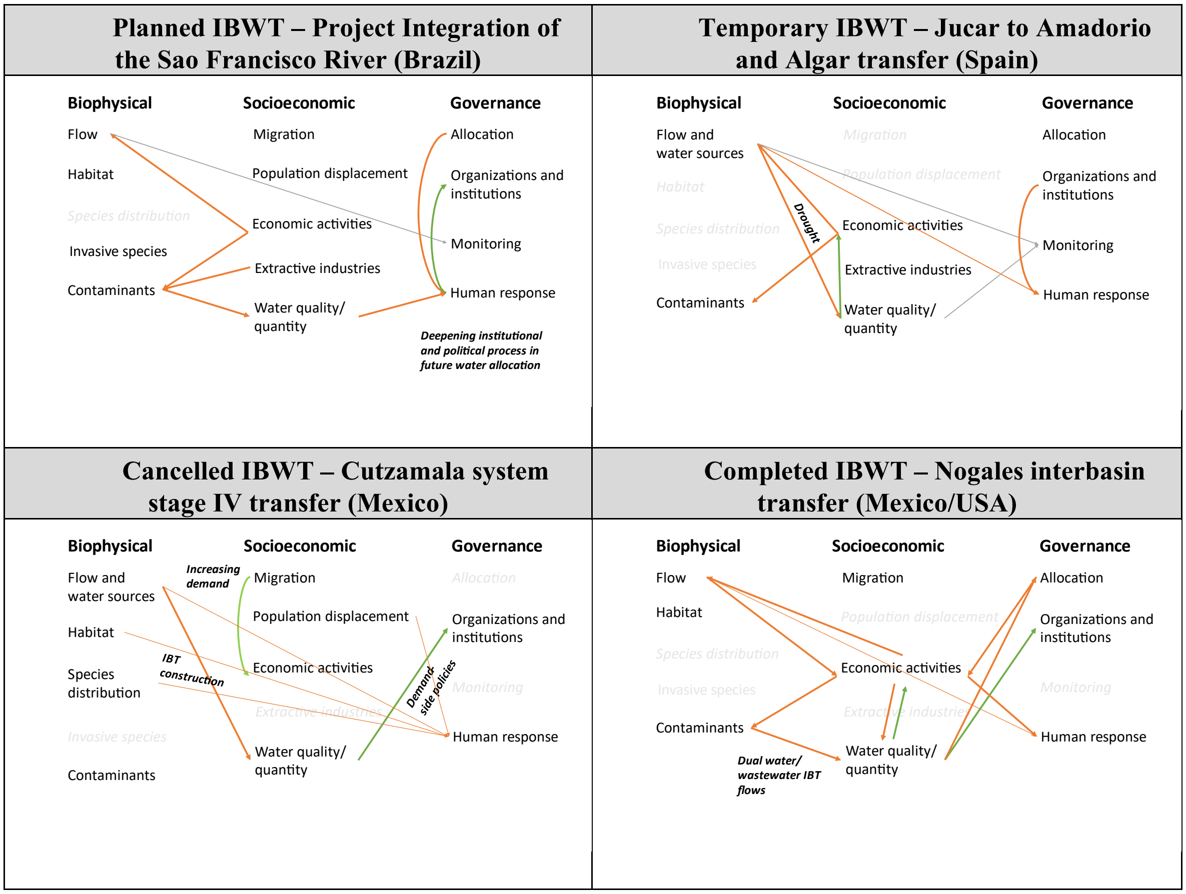

Figure 2: Webs of socionatural relations: comparison of interconnection and causal linkages of biophysical, socioeconomic and governance dimensions within 4 IBWTs in 6 cases. Key: negative effect (orange), undetermined effect (grey), or positive effect (green).[2] Source: compiled by author with information gathered from de Andrade *et al.* 2011; Lee *et al.* 2014; Sanchis-Ibor *et al.* 2019; Prichard & Scott 2014; Cabral & Ávila-García 2013.

From the cases examined, IBWTs link biophysical and socioeconomic dimensions, and the principal biophysical variable connecting across both is water flow. In Brazil, the donor river's flow is interrupted due to hydropower. In Spain, reduced flow is attributed to seasonal drought and intensive groundwater extraction for irrigation and municipal use. In Mexico, initial construction affected springs in the donor basin, while in the Nogales case diminished flow affected agriculture and ranching activities in the Los Alisos basin.

Contamination is a causal link in the socioeconomic dimension. Economic and extractive activities cause contamination, affecting water quality. In Brazil, extractive industries are found in the Sao Francisco basin, as is waste from agriculture and municipalities. In Spain, intensive agriculture in the Jucar basin caused filtering of nitrates and pesticides in groundwater for urban use. In the Nogales case, wastewater leaked into the water table in the Los Alisos basin, though treated wastewater has helped economic activity in Nogales. Disturbances to habitats and species distribution only fall into a causal link with contestations in Mexico, where rural inhabitants in the donor basin contested the IBWT's construction, fearing these disturbances would affect their livelihoods and way of life.

[2] Variables discussed in the cases are those not grayed out. Causal linkages are indicated by arrows, with colors indicating whether relationships have a negative effect (orange), an undetermined effect (grey), or a positive effect (green) on that variable's dimension. Key triggers of relationships are indicated in bold italics.

Complexity increases when socioeconomic variables link with other variables within and across dimensions. The principal conduit for relationships remains economic activity. In the case of migration, this was fueled by rural to urban migration to Mexico City. In the case of water quality and allocation politics, limited water availability reduced livelihood opportunities for ranchers in Mexico but fueled the growth of urban and industrial activity in Nogales. In the case of Spain, IBWT water kept irrigated agriculture afloat during a time of drought.

The longevity of IBWT territories

An emerging aspect of research on IBWTs concerns their actual and potential longevity. This longevity is linked to the reason for which water is transported, and these reasons can change. As seen in the following Table 2, a striking difference found in the cases is that between planned and actual water use. Of eleven cases describing this, four show differences between planned and actual water use. In addition, uses change over time. Three cases in the USA, Brazil and South Africa/Lesotho saw the number of use categories expand while one case in Australia saw categories shrink. Three of these four cases became operational between 1913 and 1949 and are the oldest IBWT ones within the sample.

IBWT name	Country	Year of operation	Planned water use	Actual water use
Paraiba do Sul	Brazil	1913	Hydropower	hydropower; urban supply
Colorado-Big Thompson Project (C-BT)	USA	1947	Irrigation	urban supply; industry; hydropower; recreation
Snowy Mountains Hydroelectric Scheme (SMHS)	Australia	1949	hydropower; irrigation; drinking water	hydropower
Telugu Ganga Project	India	1996	Drinking water	drinking water, irrigation

Table 2: Cases reporting differences in planned and actual IBWT water use. Source: de Andrade *et al*. 2011; Chokkakula 2018.

Shifts in the longevity of transfers, and differences between planned and actual use, are invariably driven by why and where water is transferred to. Within socioeconomic variables, it is water consumption that drives IBWT planning and operation, with urban supply being the primary planned and actual use. Urban areas use water to support industries, agricultural areas, and a need for drinking water. Some 13 of the 29 cases were built or were operational prior to the year 2000, and all are still operational.

Divergent hydrological imaginaries and their contestations

Reaction, resistance and contestation can become emblematic features of IBWTs. In this review, 37 contestations are reported across 28 cases. Fifteen of these explicitly identify actors in agriculture within disputes. Twelve mention government bodies at various scales. Water scarcity and/or allocation disputes exist in 19 cases. Less present are economic issues (7), and environmental concerns including habitat destruction or lack of minimum environmental flows (6). Issues of identity and rights feature in only 4 cases, but include fear of loss of rights to water (Domènech *et al*., 2013), historical prioritization of water to white farmers over other groups (Blanchon, 2017), and losses of identity and ways of life (Cabral & Ávila-García, 2013).

Overall, 22 cases identify 26 contestations being pursued by legal, technical, and/or political means.[3] Table 3 shows whether the outcomes of conflicts have changed political, socioeconomic or governance structures, and whether these contestations impacted IBWT planning or their operation:

Contestation means	Number of cases	Contestation outcome		Impact on IBWT planning/operation	
		No change	Change	No impact	Impact
Political	10	4	6	7	1
Legal	2	1	1	1	1
Technical	3	1	2	1	
Political and legal	5	2	3	2	3
Political and technical	5	4	1	3	1
Legal and technical					
Political, legal and technical	1		1		1
Total	26	12	14	14	7

Table 3: Incidence of contestation, means pursued, changes in terms of outcome, and impact on IBWT planning and operation. Source: compiled by author

How conflicts affect political, socioeconomic or governmental outcomes differs substantially across cases. The planning of Brazil's Project Integration of the Sao Francisco River spread to a national discussion regarding the desirability of megaprojects to solve water management issues (de Andrade *et al*., 2011). In Turkey's Istanbul Greater Melen project, protests against the project's social and environmental costs were ignored by authorities, but objections to land expropriation for dam construction were heeded in parliament (Islar & Boda, 2014). In Iran's Yazd and Kashan IBWTs, protests against water scarcity in donor basins led to the destruction of infrastructure (Bozorg-Haddad *et al*., 2020). A technical response includes the establishment of a river basin organization in Brazil's Paraiba do Sul IBWT (de Andrade *et al*., 2011).

The combination of political and legal means often sees political contestations linked with judicial or legislative changes. In Spain, the Ebro Transfer Scheme was subjected to protests against supply-side water policies, and subsequently cancelled by the Spanish High Court (Gupta & van der Zaag, 2008) leading to donor and recipient basins legislating water claims (De Stefano & Hernández-Mora, 2018). In Nepal's Melamchi Water Supply project, various issues led to protests from rural inhabitants, urban activists and the urban poor including disparities between rich and poor and urban and rural, international loan conditions financing the project, and livelihood destruction. These protests resulted in increased compensation for affected rural inhabitants, an expansion in the number of village development committees affected by the project, and the partial halting of water privatization (Domènech *et al*., 2013).

The combination of all three means occurred in Bolivia's Yungas de Vandiola Interbasin Irrigation Water Transfer Project (Lopez *et al*., 2019). Proposed expansion of an existing scheme created conflict, benefitting more communities at the expense of irrigation associations. The technical papers for the project were contested by non-beneficiaries, legal vetoes by the National Service of Protected Areas were rescinded when the redesigned project no longer affected a national park, and non-beneficiaries mobilized to get the regional government and international financiers to withdraw support and ultimately cancel the expansion.

[3] The terms political, legal and technical refer to tactics used in contestations. Political means are those that resort to popular mobilisation. Legal means refer to contestations using judicial processes. Technical means are those that resort to governance or engineering solutions.

There are fewer examples of how contestations impacted IBWT planning or operation, suggesting a 'durability' of IBWTs as infrastructural and water management assemblages. Contestations against the Ebro Transfer Scheme and the Yungas de Vandiola Interbasin Irrigation Water Transfer Project led to their cancellation. In the Melamchi Water Supply project, the contestation process forced the IBWT operator to shift from international to local control, and resulted in increased compensation for rural inhabitants. Yet for the most part IBWT planning and operations weather controversies and resistance.

Following the multi-dimensional analysis exemplified in Figure 2, contested outcomes act as a conduit between the three 'variables' – biophysical, socioeconomic and governance. In two cases contestation led to positive and negative changes to organizations or institutions. In Brazil, it led to alterations in the institutional decision-making process for water allocation, while in Spain, irrigation associations lost a legal case to be compensated for water restrictions during the emergency drought period. Contested IBWTs are reactions to expected or actual changes in biophysical and socioeconomic variables. The Cutzamala phase 4 IBWT was cancelled because of these anticipated changes, and also because ranchers sought compensation.

4. Discussion

This section explores how IBWTs brought about social and ecological changes to hydrosocial territories, what features were changed, of these territories change, how these changes conceptually inform hydrosocial territories, and what consequences are there for understanding contestations.

IBWTs and changes in dimensions

Both water governance and political ecology of water literatures have documented IBWT impacts, and this review supplements these by identifying IBWT territorialities as those with highly unequal yet interlinked costs and benefits across biophysical and socioeconomic dimensions. Prior IBWT reviews documented flow disruptions, contamination, introduction of non-native species, salinization and the loss of habitats (Shumilova *et al*., 2018) There were also negative environmental impacts and poor irrigation outcomes (Purvis & Dinar, 2020). The review identifies contamination, economic activities and migration as additional features of hydrosocial territorial change when IBWTs are planned or constructed. This adds further nuance to the mixed bag of advantages and disadvantages of IBWTs that scholars have identified (Gupta & van der Zaag, 2008; Purvis & Dinar, 2020; J.-D. Rinaudo & Barraqué, 2015; Shumilova *et al*., 2018). Changes to governance emerge either from contestations or from changes in water quality and quantity. In Brazil's Sao Francisco River project, there have been deepening water governance problems. The IBWT-wide hydrosocial territorial web can be controlled to benefit certain actors in donor and some recipient basins through specific imaginaries (Hommes & Boelens, 2017).

Changes in biophysical and socioeconomic variables prior to and post-IBWT operation show a range of degrading conditions. Most schemes degrade biophysical elements: water flows are disturbed, some cases show a loss of species and introduction of invasives, and contaminants increase (reversing trends due to IBWT operation). Also, donor basin economic activities diminish while those in recipient basins increase, and outmigration and community displacement occurs as people leave donor basins.

This review offers a partial snapshot of the multitude of mutable relationships IBWTs change and generate. The cases reviewed here focused on actual or potentially negative impacts, but some areas of IBWTs that were not the focus of research – such as the cities of Mexico City, Nogales, urban and intensely irrigated areas of south east Spain, and, in the future, the north east region of Brazil – greatly benefitted from water supplied by IBWTs. Prioritizing water supply to specific places and through processes involving displacement, livelihood loss and ecological destruction is a political choice that questions the viability of water-based inter-generational justice and socio-natural integrity (Zwarteveen & Boelens, 2014). Its materialization is nonetheless fashioned through discursive means.

Modern regimes within IBWT territories

IBWTs have become permanent fixtures of a hydrosocial territory, engendering changes in how water is obtained, allocated, used and disposed of. The earliest example of an ongoing functional IBWT dates to 1913.

Their flexibility allows shifts in the purposes for which water is transferred (see table 2). Rinaudo & Barraqué (2015) and Shumilova *et al.* (2018) show that IBWTs adapt to changing water use needs. Conflicts occur between groups and across scales, as a result of physically connecting different basins, and bringing into collision different imaginaries of what territory should look like, as well as different ideas about who and what should be included and excluded in those territories (Hommes & Boelens, 2017; Nightingale, 2018). Contestations are likely to continue as new generations of IBWTs get constructed and age (Shumilova *et al*., 2018). Since 2000 the number of IWBTs built has increased, and various water uses emerge (such as minimum environmental flows) and dwindle (e.g. some agriculture) in step with broader socioeconomic changes.

Yet while uses of waer change, the perception of guaranteed availability may not, because IBWT water tends to be viewed as a *natural* part of a recipient basin's water supply. As discussed by Kolinjivadi *et al*. (2020), modern regimes standardize socionatural relations, and the long duration of most IBWTs is evidence of strong control over water supply by privileged zones, independent of water's own rhythms. While there are few IBWTs that are over 50 years old, those few that do continue operating and adapting are a testament to IBWTs' permanence in hydrosocial territories as well as the priority assigned to urban areas, irrigated agriculture, or hydropower generation.

For this reason IBWTs are costly in time and finance. Their construction requires a revenue stream coming from transformed rural and urban environments; whether urban expansion and economic growth, or through irrigation providing export-friendly agricultural products and accelerated growing cycles. Gupta & Van der Zaag (2008, p. 31) argue that IBWTs can lock in the special interests of financiers, politicians and engineers who benefit from and service the infrastructural complex for decades, and this review suggests that this is a product of modern socionatural regimes of discipline and control. Accounting practices for water set in, developmental visions of territorial transformation are realized (as in the Nogales case) or idealized (as in the case of Brazil's Sao Francisco River), and alternatives to IBWTs become less feasible. This is visible in cases where IBWTs have transformed patterns of human migration, but also in cases where authorities ignored protests, such as in Turkey's Istanbul Greater Melen project. Socionatural regimes realize imaginaries of how water and power should flow, but that does not mean that an IBWTs' permanence is pre-figured.

Connected basins, contested territories

By physically moving water from one basin to another, IBWTs not only disrupt established biophysical parameters, but also human modes of production and their fit within territories. In some cases, water transfers pit different human communities against each other by creating highly interconnected but unequal hydrosocial territories.

The review of literature found that a majority of cases reported resulting conflicts, and while a majority of these are linked to allocation disputes, some are linked to concerns over losses of (mainly traditional agricultural) livelihoods, identities and rights, as well as environmental destruction. Three examples from the review exemplify this dynamic. In the case of the cancellation of Mexico's Cutzamala system stage IV, donor basin inhabitants aimed to defend not only their water sources but also linked habitats, biodiversity and ways of life against Mexico City, an increasingly thirsty metropolis (Cabral & Ávila-García, 2013). In Spain, the cancellation of the Ebro transfer involved the mobilization of social movements that urged the consideration of water's environmental and spiritual dimensions (Gupta & van der Zaag, 2008). In Bolivia, the halting of the Yungas de Vandiola Interbasin Irrigation Water Transfer Project occurred through the mobilization of diverse arrays of irrigation associations, farmers groups, and political parties well beyond the river basins in question, as well as funding groups in Europe, who together mobilized issues of equity to deny expansion of water allocation to established users of an already existing IBWT (Lopez *et al*., 2019).

While Gupta & Van der Zaag (2008) note that IBWTs serve economic heartlands, the resistance to changes wrought by IBWTs by those contesting them can be read as a defense of territory, of ways of life, and even of shifting public attitudes to discourses on water. Hommes & Boelens's (2017) idea of "contested imaginaries of territorial crafting within hydrosocial territories" provides powerful conceptual backing to this review, and supports the analysis of material and discursive changes behind shifts in hydrosocial territories. At the same time, the standardization (Kolinjivadi *et al*., 2020) and disciplining of water supply wrought by modern socionatural regimes strengthens discursive power through IBWT planning and operation. IBWTs may be seen as an illegitimate water grab by inhabitants who practice specific territorially-based and territorially-dependent livelihoods, but also a discursive well-being that emerges from livelihoods, shared communities and shared land and waterscapes. This is coherent with the cases of cancelled IBWTs seen in Mexico and Bolivia, and partly in Spain. Both material and discursive wellbeing come under threat when communities and practices disappear. Underpinning these transformations are imaginaries (Hommes & Boelens, 2017), an array of actors who wield them, and the power they mobilize to realize them. Hydraulic imaginaries are backed by popular and material power that shuts down dissent and proposals for alternatives to IBWTs.

Some contestations have few results, while in other cases there are none. Transformations of socionatural relations affect different groups in different ways (Cote & Nightingale, 2012; Fabinyi *et al*., 2014). An absence of contestations also shows how "silent" injustices pass by with little notice (Zwarteveen & Boelens, 2014, p. 152). Surprising absences include the scale of displacements and economic disruption caused by China's South to North Water Transfer's Middle route. Another example is Turkey's Istanbul Greater Melen project, where authorities ignored protests. In these cases, state processes create subjects unable to protest openly (Nightingale, 2018), because communities understand where absolute authority emanates from – locally, or from the state. The question of whose imaginary of a socionatural regime becomes realized, at the expense of more socionaturally just territories, shifts attention to power.

There are three factors underpinning hydrosocial territorial changes and resistance to IBWTs. First is the inhabitants' attachment to specific hydrosocial territories, and association with livelihoods and habitats. Second is their integration in scalar processes of state-making and capital. And third, in some cases such as Mexico and Bolivia, inhabitants make a counterclaim to gain control over narratives and, subsequently, over actual water. Many struggles against IBWTs have little to no impact on their planning and operation.

5. Conclusion

In this critical review of IBWTs I have demonstrated how they shift hydrosocial territories into new, albeit difficult, arrangements. I documented where IBWTs change features of hydrosocial territories unequally – through contamination, prioritization and reconfiguration of economic activities in specific basins, and population movements. These topics have been lacking in the emerging literature on the political ecology of water transfers, as well as in water governance. IBWTs can cause the disintegration of existing ecosystems, and of the socioeconomic systems of communities residing in donor basins. They fashion new hydrosocial territories and subject them to broader and deeper processes of capital accumulation following modern socionatural regime logics (Kolinjivadi *et al*., 2020). Nonetheless, IBWTs are ongoing and never predetermined, and they create messy outcomes of conflicting imaginaries (Hommes & Boelens, 2017) where the state aims to exercise power in terms of who and, more particularly, what hydrosocial territories "belong" (Nightingale, 2018).

Examining IBWTs from a socionatural perspective also points to new ways of focusing on the political implications of socionatural degradations of multiple, interconnected territories and dimensions. The IBWTs reviewed here show that there is little sense to adapt to changing circumstances if specific communities are displaced, the habitats and species they know disappear, or if protests and demands for change are neutralized or ignored. At the same time, the analysis of socionatural regimes and their discursive elements (Escobar, 1999; Kolinjivadi *et al*., 2020) can show how societies re-articulate water and hydrological infrastructure in such a manner that an IBWT is considered indispensable, and water delivery is recast within modernist conditions. These two contributions provide ways to rethink, conceptualize and answer questions of socio-natural justice (Zwarteveen & Boelens, 2014), and contribute to imagining what a just, equitable hydrosocial territory contains, for humans as well as non-humans.

This is important, considering that this review has shown that IBWT governance is often challenged by the actors involved. That so many conflicts and contested processes remain unresolved is a failure of water governance, and merits questioning to what extent IWRM is able to heed this challenge. Contestations have focused on the loss of livelihoods, material wellbeing, identities and patrimony linked to biodiversity and habitat (Douguet & O'Connor, 2003). They also focus on reimagining and revaluing water in ways that sit awkwardly, if not in direct opposition, to processes of state-making (Nightingale, 2018) and remaking territories along specific imaginaries (Hommes & Boelens, 2017). Seen socionaturally, these very political imaginaries come into relief and can be mapped in their complexity.

What has this review not been able to do? While they work with the idea of hydrosocial territories, most of the articles reviewed did not go deeply into issues of custom or culture that point at local understandings of how people and territories are co-constituted alongside water through IBWTs. This is an important nuance to better understand how individuals within communities grounded in specific hydrosocial territories are positioned *vis à vis* each other and their relation with water. It highlights the limits of a critical literature review, in which contextual information is presented. Further ethnographic research could focus more on the realization of competing imaginaries within particular interconnected territories. Similarly, moments and conditions that precipitate shifts in hydrosocial territories could be examined through the integral webs of relations that co-constitute territories. Here, IBWTs play an ongoing role through their historical insertion in those territories, and their role in subjectification of humans and non-humans into modern socionatural regimes. In this respect, feminist intersectional methodologies can question the scale of "community", and better understand the influence of individuals' embodied experiences and actions on the enactment of visions and interests from their positions within and in relation to hydrosocial territory.

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Appendix 1 – Articles reviewed

Article ID	Case ID	Article name (author year)	Reference
1	1; 2; 3; 4; 5	de Andrade *et al.* 2011	Andrade, José Geraldo Pena de, Paulo Sergio Franco Barbosa, Luiz Carlos Alves Souza, and Daniel Lucas Makino. 2011. "Interbasin Water Transfers: The Brazilian Experience and International Case Comparisons." *Water Resources Management* 25 (8): 1915–34. https://doi.org/10.1007/s11269-011-9781-6.
2	6; 7	Islar and Boda 2014	Islar, Mine, and Chad Boda. 2014. "Political Ecology of Inter-Basin Water Transfers in Turkish Water Governance." *Ecology and Society* 19 (4). https://doi.org/10.5751/ES-06885-190415.
3	8; 9.1; 9.2; 10.1; 10.2	Bourblanc and Blanchon 2014	Bourblanc, Magalie, and David Blanchon. 2014. "The Challenges of Rescaling South African Water Resources Management: Catchment Management Agencies and Interbasin Transfers." *Journal of Hydrology* 519 (PC): 2381–91. https://doi.org/10.1016/j.jhydrol.2013.08.001.
4	11.1; 11.2; 11.3	Shao and Wang 2003	Shao, Xuejun, and Zhaoyin Wang. 2003. "Interbasin Transfer Projects and Their Implications: A China Case Study." *International Journal of River Basin Management* 1 (1): 5–14. https://doi.org/10.1080/15715124.2003.9635187.
5	8; 9.1; 11; 12; 13; 13.1; 13.2	Gupta and van der Zaag 2008	Gupta, Joyeeta, and Pieter van der Zaag. 2008. "Interbasin Water Transfers and Integrated Water Resources Management: Where Engineering, Science and Politics Interlock." *Physics and Chemistry of the Earth* 33 (1–2): 28–40. https://doi.org/10.1016/j.pce.2007.04.003.
6	14-18	Bozorg-Haddad *et al.* 2020	Bozorg-Haddad, Omid, Mahyar Abutalebi, Xuefeng Chu, and Hugo A. Loáiciga. 2020. "Assessment of Potential of Intraregional Conflicts by Developing a Transferability Index for Inter-Basin Water Transfers, and Their Impacts on the Water Resources." *Environmental Monitoring and Assessment* 192 (1): 1–16. https://doi.org/10.1007/s10661-019-8011-1
7	19; 35	Molle and Sanchis-Ibor 2019	Molle, François, and Carles Sanchis-Ibor. 2019. Irrigation Policies in the Mediterranean: Trends and Challenges. *Global Issues in Water Policy*. 22. https://doi.org/10.1007/978-3-030-03698-0_10

Article ID	Case ID	Article name (author year)	Reference
8	11; 11.1; 11.2	Rogers *et al.* 2020	Rogers, Sarah, Dan Chen, Hong Jiang, Ian Rutherfurd, Mark Wang, Michael Webber, Britt Crow-Miller, *et al.* 2020. "An Integrated Assessment of China's South—North Water Transfer Project." *Geographical Research* 58 (1): 49–63. https://doi.org/10.1111/1745-5871.12361
9	20	Ben Fraj *et al.* 2019	Fraj, Wafa Ben, Mohamed Elloumi, and François Molle. 2019. "The Politics of Interbasin Transfers: Socio-Environmental Impacts and Actor Strategies in Tunisia." *Natural Resources Forum* 43 (1): 17–30. https://doi.org/10.1111/1477-8947.12165
10	21	Lopez *et al.* 2019	Lopez, Rígel Rocha, Rutgerd Boelens, Jeroen Vos, and Edwin Rap. 2019. "Hydrosocial Territories in Dispute: Flows of Water and Power in an Interbasin Transfer Project in Bolivia." *Water Alternatives* 12 (1): 267–2842031.
11	12	de Stefano and Hernández-Mora 2018	Stefano, Lucia De, and Nuria Hernández-Mora. 2018. "Multi-Level Interactions in a Context of Political Decentralization and Evolving Water-Policy Goals: The Case of Spain." *Regional Environmental Change* 18 (6): 1579–91. https://doi.org/10.1007/s10113-018-1318-6
12	22	Chokkakula 2018	Chokkakula, Srinivas. 2018. "Transboundary Politics of Cooperation: Telugu Ganga P*roject, India." Regional Environmental Change* 18 (6): 1645–54. https://doi.org/10.1007/s10113-018-1348-0
13	8; 9.1	Blanchon 2017	Blanchon D. (2017) Who Runs the Orange River Oasis? A Case Study of the Midstream Orange River Oasis, Northern Cape Province, South Africa. In: Lavie E., Marshall A. (eds) *Oases and Globalization*. Springer. https://doi.org/10.1007/978-3-319-50749-1_6
14	23	Ruf 2017	Ruf, Thierry. 2015. "Transférer l'eau Du Rhône Dans Le Languedoc: Regard Critique Sur Les Incidences Du Projet Aqua Domitia et Les Contradictions Territoriales." *Territoire En Mouvement Revue de Géographie et Aménagement* 25–26: 1–24. https://doi.org/10.4000/tem.2778
15	11	Rogers *et al.* 2016	Rogers, Sarah, Jon Barnett, Michael Webber, Brian Finlayson, and Mark Wang. 2016. "Governmentality and the Conduct of Water: China's South–North Water Transfer Project." *Transactions of the Institute of British Geographers* 41 (4): 429–41. https://doi.org/10.1111/tran.12141
16	24	Sanchis-Ibor *et al.* 2019	Sanchis-Ibor, Carles, Marta García-Mollá, Teresa Torregrosa, Mar Ortega-Reig, and Martín Sevilla Jiménez. 2019. "Water Transfers between Agricultural and Urban Users in the Region of Valencia (Spain). A Case of Weak Governance?" *Water Security* 7 (November 2018): 100030. https://doi.org/10.1016/j.wasec.2019.100030

Article ID	Case ID	Article name (author year)	Reference
17	19	Garrick *et al.* 2018	Garrick, Dustin E., Nuria Hernández-Mora, and Erin O'Donnell. 2018. "Water Markets in Federal Countries: Comparing Coordination Institutions in Australia, Spain and the Western USA." *Regional Environmental Change* 18 (6): 1593–1606. https://doi.org/10.1007/s10113-018-1320-z
18	11.2	Pohlner 2016	Pohlner, Huw. 2016. "Institutional Change and the Political Economy of Water Megaprojects: China's South-North Water Transfer." *Global Environmental Change* 38: 205–16. https://doi.org/10.1016/j.gloenvcha.2016.03.015
19	25	Magrin 2016	Magrin, Géraud. 2016. "The Disappearance of Lake Chad : History of a Myth." *Journal of Political Ecology* 23 (1): 204–22. https://doi.org/10.2458/v23i1.20191.
20	11.2	Deines *et al.* 2016	Deines, Jillian M., Xiao Liu, and Jianguo Liu. 2016. "Telecoupling in Urban Water Systems: An Examination of Beijing's Imported Water Supply." *Water International* 41 (2): 251–70. https://doi.org/10.1080/02508060.2015.1113485
21	9.1; 9.2	Blanchon 2015	Blanchon, David. 2015. "Le Lesotho Highland Water Project, Ou Le Retour de La Grande Hydraulique En Afrique Australe." *Bulletin de l'association de Géographes Français* 92 (2): 167–83. https://doi.org/10.4000/bagf.594
22	26	Cokorilo *et al.* 2015	Cokorilo, Marina, Zoran Stevanovic and Vesna Ristic Vakanjac. 2015. "Environmental Aspects of Proposed Engineering Solution for Inter-basin Transfer in East Herzegovina." In Lollino G., Manconi A., Guzzetti F., Culshaw M., Bobrowsky P., Luino F. (eds) *Engineering Geology for Society and Territory* - Volume 5. Springer. https://doi.org/10.1007/978-3-319-09048-1_99
23	27.1; 27.2	Prichard and Scott 2014	Prichard, Andrea Harrop, and Christopher A. Scott. 2014. "Interbasin Water Transfers at the US-Mexico Border City of Nogales, Sonora: Implications for Aquifers and Water Security." *International Journal of Water Resources Development* 30 (1): 135–151. https://doi.org/10.1080/07900627.2012.755597.
24	3	Lee *et al.* 2014	Lee, Hannah, Zamyla Chan, Kai Graylee, Arani Kajenthira,Daniela Martínez and Andrei Roman. 2014. "Challenge and response in the São Francisco River Basin" *Water Policy* 16 (1): 153-200
25	28	Domènech *et al.* 2013	Domènech, Laia, Hug March, and David Saurí. 2013. "Contesting Large-Scale Water Supply Projects at Both Ends of the Pipe in Kathmandu and Melamchi Valleys, Nepal." *Geoforum* 47: 22–31. https://doi.org/10.1016/j.geoforum.2013.02.002
26	29	Cabral and Ávila-García 2013	Cabral, Valentina Campos, and Patricia Ávila-García. 2013. "Entre Ciudades y Presas. Oposición Campesina Al Trasvase de Agua y La Defensa Del Río Temascaltepec, México." *Revista de Estudios Sociales* 6 (46): 120–33. https://doi.org/10.7440/res46.2013.12

Appendix 2 – IBWT case basic information

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
1	1	de Andrade *et al.* 2011	South America	Brazil	Paraiba do Sul	Paraiba do Sul	-	Guandu River	Inter	built	1913
2	1	de Andrade *et al.* 2011	South America	Brazil	Sistema Cantareira project	Piracicaba River basin	-	Alto Tietê River basin	Inter	built	1973
3	1	de Andrade *et al.* 2011	South America	Brazil	Project Integration of the Sao Francisco River (PISF)	São Francisco	-	Small coastal basins (North route: Jaguaribe, Apodi, Piranhas and Brigida rivers; East route: Paraíba and Moxotó rivers and the Agreste Pernambucano region)	Inter	planned	Not applicable
3	24	Lee *et al.* 2014	South America	Brazil	Project Integration of the Sao Francisco River (PISF)	São Francisco	-	Small coastal basins (North route: Jaguaribe, Apodi, Piranhas and Brigida rivers; East route: Paraíba and Moxotó rivers and the Agreste	Inter	planned	Not applicable

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
								Pernambucano region)			
4	1	de Andrade *et al.* 2011	North America	USA	Colorado-Big Thompson Project (C-BT)	Colorado River Basin	-	Front Range	Inter	built	1947
5	1	de Andrade *et al.* 2011	Oceania	Australia	Snowy Mountains Hydroelectric Scheme (SMHS)	Snowy River	-	Murray and the Murrumbidgee rivers	Inter	built	1949
6	2	Islar and Boda 2014	Middle East and North Africa	Turkey	Istanbul Greater Melen project	Melen river	-	Istanbul city	Inter	planned	Not applicable
7	2	Islar and Boda 2014	Middle East and North Africa	Turkey	Ankara Kizilirmak plan	Kizilirmak river	-	Ankara city	Inter	planned	Not applicable
8	3	Bourblanc and Blanchon 2014	Sub-Saharan Africa	South Africa	Orange River Development Project (ORDP)	Orange river basin and Vaal river sub-basin	-	Great Fish and Sunday rivers sub-basins	Inter	built	1970?
8	5	Gupta and van der Zaag 2008	Sub-Saharan Africa	South Africa	Orange River Development Project (ORDP)	Orange river basin and Vaal river sub-basin	-	Great Fish and Sunday rivers sub-basins	Inter	built	1977
8	13	Blanchon 2017	Sub-Saharan Africa	South Africa	Orange River Development Project (ORDP)	Orange river basin and Vaal	-	Great Fish and Sunday rivers sub-basins	Inter	built	1977

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
						river sub-basin					
9.1	3	Bourblanc and Blanchon 2015	Sub-Saharan Africa	South Africa, Lesotho	Lesotho Highlands Water Project (LHWP)	Senqu (Orange) river sub-basin	-	Vaal river sub-basin	Intra	built	before 1992
9.1	5	Gupta and van der Zaag 2008	Sub-Saharan Africa	South Africa, Lesotho	Lesotho Highlands Water Project (LHWP)	Senqu (Orange) river sub-basin	-	Vaal river sub-basin	Inter	built	-
9.1	13	Blanchon 2017	Sub-Saharan Africa	South Africa, Lesotho	Lesotho Highlands Water Project (LHWP)	Senqu (Orange) river sub-basin	-	Vaal river sub-basin	Intra	built	1998
9.1	21	Blanchon 2015	Sub-Saharan Africa	South Africa, Lesotho	Lesotho Highlands Water Project (LHWP)	Senqu (Orange) river sub-basin	-	Vaal river sub-basin	Intra	built	-
9.2	3	Bourblanc and Blanchon 2015	Sub-Saharan Africa	South Africa, Lesotho	Lesotho Highlands Water Project (LHWP)	Senqu (Orange) river sub-basin	-	Vaal river sub-basin	Intra	planned	Not applicable
9.2	21	Blanchon 2015	Sub-Saharan Africa	South Africa, Lesotho	Lesotho Highlands Water Project (LHWP)	Senqu (Orange) river sub-basin	-	Vaal river sub-basin	Intra	planned	Not applicable
10.1	3	Bourblanc and	Sub-Saharan Africa	South Africa, Lesotho	Tugela-Vaal	Tugela river basin	-	Vaal river sub-basin	Inter	built	before 1992

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
		Blanchon 2015									
10.2	3	Bourblanc and Blanchon 2015	Sub-Saharan Africa	South Africa, Lesotho	Tugela-Vaal	Tugela river basin	-	Vaal river sub-basin	Inter	planned	Not applicable
11	5	Gupta and van der Zaag 2008	Asia	China	South to North water transfer	Yangtze river basin	-	Hai, Yellow and Huai river basins	Inter	planned	Not applicable
11	8	Rogers *et al.* 2020	Asia	China	South to North water transfer	Yangtze river basin	-	Hai, Yellow and Huai river basins	Inter	planned	Not applicable
11	15	Rogers *et al.* 2016	Asia	China	South to North water transfer	Yangtze river basin	-	Yellow	Inter	built	2013 (eastern route case 14.1); 2014 (middle route case 14.2)
11.1	4	Shao and Wang 2003	Asia	China	South to North water transfer - East route	Yangtze river basin	-	Yellow	Intra	planned	Not applicable
11.1	8	Rogers *et al.* 2020	Asia	China	South to North water transfer - East route	Yangtze river basin	-	Yellow	Inter	built	2014
11.2	4	Shao and Wang 2003	Asia	China	South to North water transfer - Middle route	Yangtze river basin (from	-	Huaihe; Haihe	intra	planned	Not applicable

Case ID*	**article ID**	**Authors and year**	**Region**	**Country/ Countries**	**IBWT name**	**Donor basin**	**Transmitting basin**	**Recipient basin**	**Inter / Intra basin transfer**	**Construction status**	**Year of operation**
						Hanjiang river sub basin)					
11.2	8	Rogers *et al.* 2020	Asia	China	South to North water transfer - Middle route	Yangtze river basin (from Hanjiang river sub basin)	-	Huaihe; Haihe	Inter	built	2013
11.2	18	Pohlner 2016	Asia	China	South to North water transfer - Middle route	Yangtze river basin (from Hanjiang river sub basin)	-	Huaihe; Haihe	Inter	built	2014
11.2	20	Deines *et al.* 2016	Asia	China	South to North water transfer - Middle route	Yangtze river basin (from Hanjiang river sub basin)	-	Huaihe; Haihe	Inter	built	2014
11.3	4	Shao and Wang 2003	Asia	China	South to North water transfer - West route	Yangtze river basin (from Tongtian, Yalong and Dadu Rivers sub-basins)	-	Yellow	Intra	planned	Not applicable
12	5	Gupta and van der Zaag 2008	Europe	Spain	Ebro Transfer Scheme	Ebro river basin	-	South-East basin	Inter	Cancelled	Not applicable
12	11	de Stefano and Hernández-Mora 2018	Europe	Spain	Ebro Transfer Scheme	Ebro river basin	-	South-East basin	Inter	Cancelled	Not applicable

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
13	5	Gupta and van der Zaag 2008	Asia	India	River Linking Programme	various	-	various	Inter	planned	Not applicable
13.1	5	Gupta and van der Zaag 2008	Asia	India	Peninsular River Development programme	various	-	various	Inter	planned	Not applicable
13.2	5	Gupta and van der Zaag 2008	Asia	India	Himalayan Rivers programme	various	-	various	Inter	planned	Not applicable
14	6	Bozorg-Haddad *et al.* 2020	Middle East and North Africa	Iran	Behesht abad	Chaharmahal and Bakhtiari	-	Isfahan, Yazd, Kerman	-	halted	Not applicable
15	6	Bozorg-Haddad *et al.* 2020	Middle East and North Africa	Iran	Tabriz	Miandoab	-	Tabriz	-	built	1999
16	6	Bozorg-Haddad *et al.* 2020	Middle East and North Africa	Iran	Chaloos	Gilan	-	Mazandaran	-	planned	Not applicable
17	6	Bozorg-Haddad *et al.* 2020	Middle East and North Africa	Iran	Kashan	Zayandeh-Rood	-	Kashan	-	planned	Not applicable
18	6	Bozorg-Haddad *et al.* 2020	Middle East and	Iran	Yazd	Zayandeh-Rood	-	Yazd	-	built	1999

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
			North Africa								
19	7	Molle and Sanchis-Ibor 2019	Europe	Spain	Tajo-Segura Water Transfer Scheme	Tajo	Jucar	Segura	inter	built	-
19	17	Garrick *et al.* 2018	Europe	Spain	Tajo-Segura Water Transfer Scheme	Tajo	Jucar	Segura	Inter	built	-
20	9	Ben Fraj *et al.* 2019	Middle East and North Africa	Tunisia	Northern water master plan (?)	Far North coastal basins	Ichkeul Basin	Greater Tunis; Cap Bon; Sfax and Eastern Tunisia	Inter	built	1994 onwards
21	10	Lopez *et al.* 2019	South America	Bolivia	Yungas de Vandiola Interbasin Irrigation Water Transfer Project	Yungas de Vandiola basin	-	Pucara watershed	inter?	halted	Not applicable
22	12	Chokkakula 2018	Asia	India	Telugu Ganga Project	Krishna river	-	Pennar river	Inter	built	1996
23	14	Ruf 2017	Europe	France	Aqua Domitia	Rhone river basin	-	Previously Barcelona; currently Aude river (Narbonne)	Inter	planned	Not applicable
24	16	Sanchis-Ibor *et al.* 2019	Europe	Spain	Jucar to Amadorio and Algar transfer	Jucar	-	Amadorio and Algar rivers	Intra	built	1999-2001

Case ID*	article ID	Authors and year	Region	Country/ Countries	IBWT name	Donor basin	Transmitting basin	Recipient basin	Inter / Intra basin transfer	Construction status	Year of operation
25	19	Magrin 2016	Sub-Saharan Africa	Chad, Cameroon, Nigeria, Niger, Central African Republic	Congo basin to Chad lake basin water transfer	Congo river basin	-	Lake Chad	Inter	planned	Not applicable
26	22	Cokorilo *et al.* 2015	Europe	Bosnia and Herzegovina	Upper Horizons	Neretva river basin	-	Trebisnjica river basin	Inter	planned	Not applicable
27.1	23	Prichard and Scott 2014	North America	USA, Mexico	Nogales interbasin transfer	Los Alisos river basin	-	Santa Cruz river basins	Inter	built	-
27.2	23	Prichard and Scott 2014	North America	USA, Mexico	Nogales interbasin transfer	Santa Cruz river basins	-	Los Alisos river basin	Inter	built	2012
28	25	Domènech *et al.* 2013	Asia	Nepal	Melamchi Water Supply project	Melamchi valley	-	Kathmandu valley	Intra	planned	Not applicable
29	26	Cabral and Ávila-García 2013	North America	Mexico	Cutzamala system stage IV	Temascaltepec river	-	Mexico valley	Inter	Cancelled	Not applicable

* Cases with a decimal point are individual IBWTs making up part of a larger transfer scheme

Appendix 3 – Socionature variables and case descriptions

Dimension	Variable	Description
Biophysical	Basin(s)	Basic information on basins involved in IBWTs and if the IBWT is inter or intra basin water transfer is collected in appendix 2
	Flow	While flows vary due to seasonality, nearly half of the cases documenting flow modification discuss human-induced modifications to flow before IBWTs went operational, pinning the reasons on irrigation and overallocation of water resources in recipient basins. These cases reflect the justification for IBWTs in the first place, that is, a lack of water in recipient basins. These cases were found in China (Deines *et al*., 2016; Shao *et al*., 2003), Spain (Molle & Sanchis-Ibor, 2019), and Tunisia (Ben Fraj *et al*., 2019). In the north of China, water deficits are projected and expected to increase the use of groundwater, river desiccation, heavy water pollution, and the deterioration of riparian and estuarine ecosystems, and the construction of dams have interrupted water flows (Shao *et al*., 2003). In Beijing, though the city has depended on groundwater for well over 2,000 years, urban expansion has stressed supply to the point that the water table has dropped 21.7 meters leading to land subsidence, and the Hai river basin which Beijing is in has rivers running dry for more than 300 days of the year (Deines *et al*., 2016). In Spain, the Segura river basin barely has water reaching the sea, due to exploitation of all available water resources available, whether groundwater or surface water, for intense irrigated agriculture (Molle & Sanchis-Ibor, 2019). In Tunisia, a similar situation occurs, with dams allowing a distribution of water resources for irrigation and urban expansion (Ben Fraj *et al*., 2019).
	Habitat	One of the biophysical features that explores the biophysical dimension, habitat modification, is barely explored prior to IBWT planning, but is then quite well documented after IBWTs go into operation, collecting destructive consequences of IBWTs. During IBWT planning, six articles cite studies that note expected habitat disturbances, including coastal erosion and salinization in China and India. Actual recorded modifications include various phenomena. In Australia, coastal erosion occurred due to the Snowy Mountains Hydroelectric Scheme's transfer of water to the Murray and the Murrumbidgee river basins. This case was highlighted by the authors (de Andrade *et al*., 2011) for a noticeable absence of possible environmental impacts in the IBWT's planning phase. In China, phytoplankton blooms have emerged in the exposed canal of the Middle Route that makes up one of three transfers of the South to North Water Transfer. The main destination of the Middle Route is Beijing, and does not have the infrastructure to treat phytoplankton (Rogers *et al*., 2020). Lake salinity disturbances in Tunisia were attributed to the reduction of natural inflows of river water to Ichkeul lake, a UNESCO biosphere reserve since 1977 (Ben Fraj *et al*., 2019). In Mexico, a decrease in riparian vegetation downstream of urban areas was noted after the Nogales Interbasin Transfer went into operation. Nonetheless this was attributed to a decade-long drought and not to the hypothesized reduction in the water table occurring due to expansion of groundwater extraction following reduced surface water availability since the IBWT started operation (Prichard & Scott, 2014). The only case to document measures to reduce habitat destruction is in Tunisia, which is no longer functioning following damage to infrastructure during the events of the Arab Spring (Ben Fraj *et al*., 2019).
	Species distribution	Changes in species number and distribution is even less documented, but as with habitat changes, reflects destructive changes wrought by IBWTs. Only two articles contain cases mentioning species distribution prior to IBWT planning, which includes threats to 11 endemic species reported in a WWF report for the planned Melen Project (Islar & Boda, 2014), expected impacts on aquatic salt-water species due to water abstractions from donor basins in India if the nation-wide River Linking Program goes into effect (Gupta & van der Zaag, 2008). After IBWTs went into operation, changes in species composition were documented in South Africa´s Great Fish river, one of the recipient basins of the Orange River Development Project IBWT, which included the domination of the pest blackfly species Simulium chutteri over other benign species and causing damage to livestock (Gupta & van der Zaag, 2008). In Tunisia, habitat

Dimension	Variable	Description
		modification of the Ichkeul lagoon led to the reduction in number and endangerment of rare migratory bird species (Ben Fraj *et al*., 2019). The construction of the now cancelled Cutzamala system stage IV in Mexico has led to the disappearance of animal and plant species, including those used by local human communities (Cabral & Ávila-García, 2013).
	Contaminants	Contaminants are relatively well documented among the cases, with 10 discussing the presence of contaminants prior to IBWT planning. Most of this contamination was found in water, with half of cases reporting these in recipient basins compared to slightly less than half in donor basins. Three IBWTs in particular stand out which highlight the urgency with which IBWTs are planned in periods of drought, extractive contexts for newer justifications of water transfers, and the increasing concern of contamination that governments have, but which cannot plan for unknown consequences of changing water flows. Within the planned Ankara Kizilirmak plan in Turkey, planned during a prolonged period of drought, the donor Kizilirmak River was found to have high levels of sulphate, chlorate, and heavy metals due to run-off from widespread agriculture and livestock breeding, contamination from solid waste dumping sites, and excessive salinity from local geological features (Islar and Boda 2014:4). The planned expansion of the Lesotho Highland Water Project which transfers water from Lesotho to South Africa's Gauteng region, is premised on the need by South Africa to have greater volumes of high quality water to dilute effluents from gold mining, or acid mine drainage (Blanchon 2015:168-169). In three cases where there were changes to contamination following the construction and operation of IBWTs, all were based in China's South to North Water Transfer. In this transfer's Eastern route, measures to improve water quality across all IBWT basins started prior to IBWT operation and have continued since operation, though it is feared that changes in water flow direction in lakes connected to the IBWT along the Eastern route may disturb contaminated sediments (Rogers *et al*., 2020).
Socioeconomic	Demography and habitation	IBWT planning sets in motion population movements, whether from uncertainty to rural livelihoods, relocations, or promise of further opportunities in urban areas. Operational IBWTs then set in concrete the principal artery through which urban areas can surpass the biophysical limitations that local water supplies set, to expand and attract migrants. Flows attributed to planning occurred in Turkey, China, the USA and Mexico, and nearly all flows occurred in donor basins. In Turkey, prolonged planning of the Istanbul Greater Melen project caused uncertainty for rural inhabitants, which pushed them to migrate to urban areas. In the case of the Ankara Kizilirmak plan, there is mention of some resettlement and minor impacts on rural inhabitants that live in the vicinity of Ankara and the IBWT (Islar & Boda, 2014). In China, the construction of the South to North Water Transfer's middle route, and to a lesser extent the eastern route, is expected to lead to population relocations (Shao *et al*., 2003). More broadly, construction of the whole South to North Water Transfer is expected to cause the relocation of 300,000 people (Gupta & van der Zaag, 2008). This is also not taking into account what impact on "pull factors" extra water availability in the recipient basins of China's North will have. In the USA and Mexico, the Nogales interbasin transfer has surface water transferred from the Los Alisos river basin in Mexico to the Santa Cruz river basin in the USA, and wastewater transferred back, with treatment plants on either side of the border. Continuous expansion and planning of this IBWT serves to maintain growth of the city of Nogales, which witnesses increased population growth via rural to urban migration (Prichard & Scott, 2014). Flows attributed to IBWT operation were found in Brazil, USA and Mexico, and were occurring in donor basins. The cases in Brazil, the Paraiba do Sul IBWT and the Sistema Cantareira project which serve the cities of Rio de Janeiro and Sao Paulo respectively, had the IBWTs become the principal water source that facilitated urban expansion over decades (de Andrade *et al*., 2011). Another dimension of migratory flows can be represented as community displacements caused by IBWT planning and operation. These are noted in 15 cases, found in Brazil, Turkey, China, India, the Chad lake basin, South Africa, Lesotho, Nepal and Mexico. In China (Deines *et al*., 2016; Rogers *et al*., 2016, 2020), the

Dimension	**Variable**	**Description**
		heightening of the donor basin's Danjiangkou reservoir and canal construction along transmitting basins in the South to North Water Transfer project's Middle Route displaced 402,000 people. Another 880,000 people were resettled for poverty relief, disaster relief, and pollution control upstream of the Danjiangkou Reservoir in the donor basin. In the South to North Water Transfer project's Eastern Route, 8,000 people were resettled along the transmitting basin. In Lesotho, the construction of the Lesotho Highlands Water Project which provides water to South Africa's economic heartland caused the forced displacement of villages in the donor basin's high valleys (Blanchon, 2015). One case in Mexico noted expected displacements linked to the loss of land due to construction of reservoirs for stage IV of the Cutzamala system, though social mobilization and political action by inhabitants in the donor basin were able to cancel this IBWT (Cabral & Ávila-García, 2013).
	Economic activities and agriculture and forestry	Economic activities are a reflection of water consumption. Nearly half of the cases describe economic activities in the basins prior to IBWT planning, independent of whether said activities were going to be benefitting or affected by an IBWT, with a majority of these activities being agricultural. A few cases reported on specific groups partaking in these activities, and were invariably farmers, peasants and irrigators. One case in Nepal, when describing the territories involved in the Melamchi Water Supply project, specified castes, ethnic groups and land-holding patterns in the donor basin, the Melamchi valley (Domènech, March, and Saurí 2013). After IBWT planning or operation, donor basin economic activities suffered reductions as a result of IBWT operation. In 4 cases in China and Turkey, industries were forced to cease operation and communities relocated in order to reduce polluting activities and maintain water quality to ensure water transfer. In Turkey, the Istanbul Greater Melen project requested dyeing activities in the Melen basin to cease (Islar and Boda 2014). In China, the construction of the South to North Water Transfer's Middle route has had economic activities curtailed in the region close to the Danjiangkou reservoir, the point where water is transferred from the donor basin. This has included factory closures, including turmeric processing facilities, as well as a curtailing on the use of chemical fertilizers (Rogers *et al*. 2020; Pohlner 2016). Recipient basins on the other hand saw an expansion of agricultural and industrial activities as well as of urban areas. Nonetheless two cases also pointed out livestock damage associated to IBWT operation in recipient basins. In Nogales, Mexico, livestock suffered damage due to wastewater infiltration in the water table, since this particular IBWT transfers wastewater for treatment at the recipient basin (Prichard and Scott 2014). In South Africa's Orange River Development Project, as seen earlier, the domination of particular pests in the recipient basin has also caused damage to livestock in the area (Gupta and van der Zaag 2008).
	Other extractive industries	Extractive industries are mentioned in 8 cases. These include coal and oil extraction, gold mining, sand extraction, and quarrying. These occur in three recipient basins, two transmitting basins, and one donor basin. Cases mentioned these activities in basins, but aside from a need for more, better quality water in South Africa to treat gold mining waste (Blanchon, 2015), extractive industries are not necessarily linked to IBT planning and operation.
	Water consumption	Water consumption is the driving force behind IBT planning and operation, and therefore 43 cases describe planned IBT water use. By comparison, actual IBT water use was reported by a far lesser amount, in 11 cases. Urban supply is the primary planned and actual use for water that justify IBTs. This category invariably serves as a blanket term, since urban areas represent a variety of uses, having industries, agricultural areas, and a need for drinking water too. In this respect, 17 of 23 cases describing planned water use for urban areas also included other uses, mainly water for industry. It reinforces the argument that IBTs mobilise water to serve economic heartlands which are invariably urban (Gupta & van der Zaag, 2008). Planned and actual water use reflect each other for industrial, irrigation and hydropower generation, though it falls significantly for purported drinking water use. A striking difference between planned and actual water use is

Dimension	Variable	Description
		that various categories. This is attributed to the fact that all these categories, aside from recreation, are cases of planned IBTs. Recreation emerged as a new water use in the Colorado-Big Thompson Project in the USA, after IBT operation. Similarly, of 11 cases that described planned and actual IBT water use, 4 show differences between planned and actual water use. 3 cases in the USA, Brazil and South Africa/Lesotho saw the number of use categories expand while one case in Australia saw number of categories shrink. This is shown in the following table:
Governance	Allocation	There are myriad allocation processes that involve governmental organizations, RBOs or local irrigation associations, pointing to organizational as well as institutional diversity in how IBWT water is allocated. Allocation criteria in these processes also vary greatly. In Spain, the temporary Jucar to Amadorio and Algar transfer had allocation limited if drought conditions are present (Sanchis-Ibor *et al*., 2019), while in the Tajo-Segura Water Transfer Scheme authorization started by government decree, which then shifted to permit trading (Garrick *et al*., 2018). In China's South to North water transfer, the river basin commission in the donor basin proposes allocations, which are then used by recipient basin municipalities in their water use plans (Rogers *et al*., 2016). In Bolivia's Yungas de Vandiola Interbasin Irrigation Water Transfer Project, legal agreements are drawn between irrigation associations based on water availability (Lopez *et al*., 2019). In South Africa, both the Lesotho Highlands Water Project and the Orange River Development Project have authorizations determined by water availability and minimum environmental flows (Blanchon, 2017). In Tunisia, allocations are based on needs and the volumes available, with priority given to domestic needs in both local areas and in the south (Ben Fraj *et al*., 2019). Finally, in Brazil's Sistema Cantareira project, allocations are based on licenses (de Andrade *et al*., 2011). 4 cases describe changes in allocation processes since IBWTs went into operation, which included the emergence of river basin commissions, local organizations, and market mechanisms. In Brazil, river basin commissions emerged as the preferred route in both the Paraiba do Sul and the Sistema Cantareira project (de Andrade *et al*., 2011). In Bolivia's Yungas de Vandiola Interbasin Irrigation Water Transfer Project, it was through the emergence of irrigation associations from other catchment areas (Lopez *et al*., 2019). In Spain, it was market actors acting on the introduction of permit trading (Garrick *et al*., 2018).
	Monitoring	Monitoring measures inform technical guidelines and are supposed to support water governance in making decisions that have real world impacts. Who actually conducts monitoring is not always clear, but there is a mix between government agencies, RBOs and public/private partnerships. Within IBWT-related monitoring, the sources discussed monitoring in relation to water quality (particularly to detect contaminant levels), quantity, and in the case of Tunisia's Northern Water Master Plan, Ichkeul lagoon's salinity to determine its environmental state (Ben Fraj *et al*., 2019). Water quality issues were picked up by monitoring in donor basins, including high nitrogen levels in the Chaloos IBWT in Iran (Bozorg-Haddad *et al*., 2020), and pollutants from economic activities and settlements in both the East and Middle routes of China's South to North Water Transfer (Pohlner, 2016; Rogers *et al*., 2020). In recipient basins, water quality issues found included sewage concerns in the Paraiba do Sul IBWT in Brazil (de Andrade *et al*., 2011), phytoplankton in the Chaloos IBWT in Iran (Bozorg-Haddad *et al*., 2020), and pollution in the Beijing area where all routes of China's South to North Water Transfer ultimately reach (Rogers *et al*., 2016). There are few examples of monitoring affecting IBWT operation, though examples given show that there can be institutional learning, or examples where problems are literally moved from one place to another. In Brazil, the Paraiba do Sul IBWT saw the emergence of mechanisms for conflict mediation for environmental impacts and shifts to deciding water availability during drought. These were seen as lessons learnt from previous experiences with IBWTs in Brazil (de Andrade *et al*., 2011). In the Miandoab to Tabriz IBWT in Iran, pollution was discharged into wetlands or the sea rather than into the donor basin (Bozorg-Haddad *et al*., 2020). In

Dimension	Variable	Description
		Tunisia, the Northern water master plan's IBWT passes through the Ichkeul Basin, which contains saline lagoons with high biodiversity. Here, concerns over the lagoon's salinity led to the construction of a sluice gate to regulate lagoon salinity. Nonetheless, this gate has only been used to regulate reservoir levels, never to respond to environmental issues(Ben Fraj *et al*., 2019). Monitoring has led to the introduction of policies and instruments to resolve negatively perceived alterations to ecosystems in 11 cases. These mechanisms range across a number of categories: guaranteed environmental flows, environmental impact assessments, market mechanisms, fiscal measures for municipalities, infrastructure, limitation of economic activities and relocation of settlements, and shifts of municipal water sources. Nonetheless, the only measure that reports to have had some level of success in limiting these alterations have been the limitation of economic activities and settlement relocations in China's South to North Water Transfer's Middle route (Pohlner, 2016). More often than not, alterations persist: sewage goes untreated in Brazil's Paraiba do Sul IBWT despite tariffs on users (de Andrade *et al*., 2011); The Ichkeul lagoon faces salinity crises due to infrastructure no longer functioning (Ben Fraj *et al*., 2019); groundwater is still contaminated despite no longer been abstracted in Spain's Jucar to Amadorio and Algar transfer (Sanchis-Ibor *et al*., 2019); despite industry closure in China's South to North Water Transfer's Middle route, there is saline intrusion and chlorination downstream in the donor Yangtze basin (Pohlner, 2016).
	Institutions	With the emergence of IWRM as the hegemonic set of principles to govern water in an equitable, efficient and environmental manner (Gupta & van der Zaag, 2008), RBOs are the type of organization to be expected to be present in IBWT governance in cases as of the 1990s to 2000s too, particularly to give voice to lower scale actors and territories. In this regard, only 11 cases explicitly identified RBOs present in cases where water is governed at the river basin level. 8 cases also informed whether RBOs appeared before or after an IBWT went into operation. Of these, 6 cases had RBOs appear before IBWTs went into effect, in Brazil (de Andrade *et al*., 2011), Spain (De Stefano & Hernández-Mora, 2018), France (Ruf, 2015), and the Congo Basin (Magrin, 2016). The RBOs in Brazil, Spain and France emerged out of a national requirement for these kinds of organizations to be present in water governance. In the case of the Congo Basin, the Lake Chad Basin Commission represents a basin management organization made up of national governments that share the basin (Magrin, 2016). The two cases that had RBOs appear after IBWTs went into effect were in Brazil's Sistema Cantareira project (de Andrade *et al*., 2011) and South Africa's Orange River Development Project (Bourblanc & Blanchon, 2014). Both of these cases are historical IBWTs that went into operation in the 1970s, and as such it is reasonable that RBOs appeared as water governance organizations when they became ubiquitous with IWRM.