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Modelling as Intervention Technology: Science, Politics, and Water Conflicts

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ABSTRACT: In water conflicts, models and their creators are often seen as guides that help public and policy actors make sense of controversies and formulate responses. In such contexts, it is tempting for both modellers and decision-makers to adopt the narrative that models are neutral and that, by extension, they present objective insights. This assumption, however, overlooks two critical issues. First, many choices made by modellers, which significantly shape a model's outcome, are subjective and context-dependent. Second, water conflicts are inherently sociopolitical processes, and models themselves actively shape how these conflicts unfold. This paper argues that within hydropolitical dynamics, water models become the 'focal points' of a convergence of scientific expertise, political priorities and societal values and expectations. They become 'intervention technologies' that actively shape the very water realities they seek to describe. Drawing on ethnographic research and on insights from Science and Technology Studies, this paper explores this argument through the case of a water transfer controversy in the Zayandeh-Rood River Basin in central Iran. By unpacking how modelling (and countermodelling) practices are entangled with broader sociopolitical dynamics, the paper traces how models intervene in the making of the common resource, common sense and common good, while themselves being in turn shaped by these contested arenas.

KEYWORDS: Politics of modelling, water conflict, co-production, intervention, imaginary, countermodel, common sense, common good, Zayandeh-Rood River

INTRODUCTION

Mathematical modellers have often been seen, or have seen themselves, as neutral intermediaries, simply 'carrying' scientific facts into decision-making untouched by the influence of politics, with the implications of their work left to others to interpret and act upon (see Oreskes and Conway, 2011; Saltelli et al., 2024; Shackley and Wynne, 1996; van der Sluijs, 2002; Saltelli et al., 2020b). While this view has been increasingly questioned and many modellers now engage in reflexive practices, the ideal of neutrality still persists in some modelling communities and institutional settings. It is a perspective that fails to acknowledge the deep political currents that shape every choice made at various stages of the modelling process – choices that ultimately control outcomes and create new realities (Krueger and Alba, 2022). In critical fields such as water, energy and health, modellers are often granted "exceptional epistemic authority" (Saltelli et al., 2024) to "speak on behalf" of river, power grid, or disease outbreak during times of crisis and urgency (Nabavi, 2022c). This often involves privileging certain epistemic communities while sidelining the voices of others who may not engage with modelling such as Indigenous knowledge-holders (de Sousa Santos, 2015).

This issue has led to calls for modellers to reflect on the politics embedded in their work, particularly when decisions have far-reaching social and ethical consequences (Saltelli et al., 2020a). These discussions particularly aim to highlight the politics of modelling (Saltelli and Di Fiore, 2023; Nabavi and

Razavi, 2023), and call for the creation of a new field that is dedicated to "responsible modelling and computing" (Nabavi, 2022a).

The complex relationship between water systems and their social and political contexts has long been explored in water research through concepts such as socio-hydrology, the waterscape, the hydrosocial cycle, and hydrosocial territory (Linton and Budds, 2014; Boelens et al., 2016; Karpouzoglou and Vij, 2017). More recently, increasing interdisciplinary collaboration between critical social scientists and water modellers has brought renewed attention to how water models interact with these contexts (see, for example, Krueger and Alba, 2022; Klein et al., 2024; Molle et al., 2024; ter Horst et al., 2024; Melsen, 2022). Recent special issues of the journals *Water International* (2024) and *Water Alternatives* (2024) have explored the political role of quantification in water governance, examining how data, models, indicators, thresholds and cost – benefit analyses shape policy. In their editorial, Molle et al. (2024) emphasise the need for deeper engagement with the boundary work of numbers at the science – policy interface, calling for greater scrutiny of both 'small-p' and 'big-P' politics in knowledge creation (King and Tadaki, 2018). This is what informs this paper's approach to the politics of water modelling when it confronts conflict and controversy.

Here, small-p politics refers to the subtle and often hidden ways in which negotiations and power dynamics influence choices made in modelling; these can include model assumptions, parameters, boundary conditions, method selection, data interpretation, and the framing of results. These are not the explicit politics typically associated with policy-making; rather, they comprise the more implicit, mundane and everyday politics that is embedded in modelling practices. Such elements are often treated as issues to be tamed through standardisation, through standardisation which, if 'successful', is assumed to have provided an ostensibly objective foundation for decision-making.

The challenge, however, is that even standardisation in modelling is not itself free from politics (Remmers, 2025). It involves negotiating differing perspectives on its implementation, resolving disagreements about best practices, and managing the influence of a select group in shaping the approach (which can potentially limit the representation of broader perspectives on the issue). The critique here is not directed at standardisation per se, but rather at how it can be used to foreclose political debate.

Acknowledging the inevitability of small-p politics in modelling work challenges the view of models as neutral. It regards modelling as a practice that is situated within particular social processes (Melsen, 2022; Melsen et al., 2019; Klein et al., 2024) where data and models are political (ter Horst et al., 2023).

These small-p politics often unfold within frameworks that have been established by big-P politics. A research team's choice of a specific flood model (small-p), for example, could be shaped by funding priorities and institutional preferences (big-P). As Addor and Melsen (2019) showed, water modellers around the world often develop 'strong attachments' to certain models, with preferences varying on the basis of the region where the model was developed. They argue that 'legacy' often outweighs 'adequacy' in model selection, showing in their review that three-quarters of applied hydrological models were predictable based solely on the institution of the first author.

In water conflict situations, the interplay between small- and big-P politics grows even more complex. Water conflicts are inherently sociopolitical and models play an active role in shaping these dynamics. They are not merely dragged passively into the process; rather, their very existence often shapes how these conflicts unfold. Thus in some ways it is less about whether modelling is politicised in the water conflict or used to depoliticise it (Godinez-Madrigal et al., 2020); rather, it is more about understanding how modelling as a sociotechnical process takes part in a complex web of interactions where politics is co-constructed by the modellers, by those who commission or engage with their outputs, and by the broader social and political context in which they operate.

A rich body of literature from Science and Technology Studies (STS), including anthropology, geography and environmental history, has already explored the entanglement of water, technology,

power and sovereignty. Scant attention, however, has been given to the interaction between small-p and big-P politics in the modelling space, as particularly highlighted by Molle et al. (2024). One possible reason for this lack of attention is that the implied ontological positions in STS concepts often do not require this small-p/big-P distinction to demonstrate how this entanglement is constructed.

While this distinction is not used as an analytical lens in the sections that follow, it still provides a useful entry point for understanding the political entanglements that are often left unspoken in technical modelling work. This includes how assumptions, standards and model uptake might intersect with institutional values, interests and power structures. Relying too heavily on this small/big-p binary, however, risks oversimplifying the complex and layered nature of these dynamics.

To avoid this, the paper instead draws on co-production concepts and theories from STS (Jasanoff, 2004) to explore how political effects are embedded in, and co-emerge with, modelling. This shift allows the paper to take a more situated view of politics, not as external to the model but rather as something that is continuously shaped through the model's development and use.

This paper uses, as a case study, a conflict in central Iran over a water transfer project. It shows how modelling (and countermodelling) efforts become focal points where models and politics – more specifically, hydropolitics – are co-constructed. It explores how modelling both shapes, and is shaped by, broader sociopolitical dynamics through stabilising (or destabilising) what counts as the common resource, the common sense, and the common good.

To flesh out the argument, the next section begins by discussing a constructionist approach to studying water models. It conceptualises modelling as an intervention technology and argues that the activities and responsibilities associated with modelling are always sociotechnical in nature. Adopting a co-productionist approach, the paper argues that models are not only a way of knowing; they are also a way to shape and organise institutions, identities and narratives. In this way, they are not merely the product of epistemic standards and judgments; they are also themselves shaped by societal imaginaries and narratives and they, in turn, influence how the problem is framed and how the society understands what is desirable, essential, practical and/or feasible.

In the section following on that, these dynamics and relationships are explored in detail through the case of the Zayandeh-Rood River, where the interbasin water transfer is framed as a commonsensical and almost inevitable solution to water shortages in the downstream community of Isfahan. The paper shows how this water transfer narrative constructs a new water reality in the basin by presenting a model that shows an upstream 'surplus' that is available for transfer. By erasing the injustice and harm inflicted on the upstream region, modelling makes this surplus water 'appear' in public discussions and policy circles, as if it would be wasted if not used. In response, countermodelling efforts by upstream water modellers challenge this claimed surplus; they insist that not much extra water is available and they thus make the water produced by the mainstream model 'disappear'. This making and unmaking of water, along with the sociopolitical dynamics shaping the models and being shaped by them, are detailed in the section below that analyses the case study.

A CONSTRUCTIVIST APPROACH TO STUDYING WATER MODELS

Theories and concepts in 'social constructivist' approaches (especially those in STS) challenge the notion of objective, neutral models (see, for example, Jasanoff, 2004; Latour, 1993, 1987, 2005; Wynne, 1992; Callon, 1984, 2007; Gieryn, 1983). They argue that the 'truths' produced by models are often shaped by the specific goal of creating new realities, either by opening pathways for change or by reinforcing existing narratives and power structures.

Modelling as intervention

Over the past decades, the design, development and deployment of water models have significantly expanded, driven by advancements in computational technologies (Refsgaard et al., 2007; Maity et al., 2024). These models actively participate in shaping knowledge about water systems; they define what counts as valid and credible and frame how issues are understood in society (Liu et al., 2008; Lövbrand, 2011). They lend legitimacy to particular actions or inactions and they shape perceptions of what is relevant or irrelevant, possible or impossible; ultimately, they influence what is perceived to be needed for the future (White et al., 2010; Lane et al., 2011; ter Horst et al., 2024).

In this sense, models have the quality of a technology that can 'perform' (MacKenzie, 2008; Edwards, 2013), meaning that their existence and use have a tangible effect on the world. They can change behaviours, guide decisions and shape policy based on their assumptions and projections. For water modelling, this performativity means reshaping how the 'audience' of the model (Mäki, 2011) – that is, the public, farmers and water policymakers – perceive and expect water resources and governance systems to function, now and in the future. The idea of performativity has been explored in economics by Michel Callon, who showed that once financial models like the Black-Scholes-Merton model were taken up by traders, markets began to behave in ways that mirrored the model's assumptions. As Callon (2007) put it, "the formula has become true, but it is preferable to say that the world it supposes has become actual". Thus, a model can go beyond a purely linguistic or theoretical exercise to become a technology that is "physically manipulative, interventionist, and creative" (Hottois, 2018; for more see Hottois, 2019).

Building on this in the context of water controversies, particularly those fraught with politics, modelling has become more than just "technology for investigation" (Morrison and Morgan, 1999); it has come to function as "technology for intervention", performing in ways that significantly shape deeply political decisions. Using a model to investigate hypotheses or evaluate scenarios can of course also be considered an intervention, as the model can highlight specific outcomes and steer stakeholders towards particular courses of action that may not have otherwise been considered. Beyond this, however, modelling can be leveraged to challenge or to reinforce mainstream narratives (Godinez-Madrigal et al., 2020; de Souza et al., 2025).

All of this challenges the ideal of models as apolitical, neutral intermediaries that merely carry scientific facts; instead, it highlights the social and political dynamics that shape the design of models and the knowledge they produce. In this context, knowledge and action co-produce one another, with models acting as 'active participants' that both influence, and are influenced by, existing knowledge, decisions and power relations (Nabavi and Daniell, 2017). Through actor network theory (Latour, 1993, 2005), this co-production is seen as unfolding within complex networks of human and nonhuman actors, involving symbolic practices and material processes.

For this reason, the article foregrounds modelling (not the model itself) as a situated and ongoing process through which knowledge, authority and legitimacy are co-produced and contested. It conceptualises modelling as a site where natural and social orders are co-created (Jasanoff, 2004), where assumptions about water systems, governance priorities and acceptable risks are built into the thinking about, making of, interpreting of models, and their promotion. In this way, modelling intervenes not only in the material governance of water as a physical resource but also in the demarcation of claims to authority and legitimacy (Gieryn, 1983).

Countermodels

Because models influence which options are seen as feasible or legitimate, they often become sites where politics and modelling are deeply entangled. This entanglement creates space for alternative perspectives to challenge the assumptions, values and outcomes embedded in dominant or mainstream models, which can, in the process, bring about a redistribution of power. Since models are developed

with particular goals and applications in mind, their structure and direction are shaped by those intentions. Objections thus often arise from those who see the aims, methods or conclusions of mainstream models as being incomplete, biased or misaligned with their social or environmental concerns. These tensions open up a dynamic space for critique and contestation.

The analytical dimension

One powerful way critics engage in debates around modelling is by developing countermodels. In fields that rely on formal logic, such as computer science, countermodels are typically used to disprove universal claims or to demonstrate the invalidity of system specifications by revealing conditions under which assumptions or claims can be contested or falsified (Negri, 2014). A constructivist view of modelling, however, offers an expanded definition that captures the social and political work done by countermodelling beyond its purely epistemic role. Thus, countermodelling can be seen as a critical site where narratives are validated (or rejected) and where authority and legitimacy are reinforced or contested, all of which carries potential social and political implications.

A countermodel presents an alternative viewpoint that questions mainstream calculations and conclusions and offers a different interpretation of water reality. When successful, a countermodel can undermine the authority and legitimacy of the dominant model and of the actions or plans based on it. This invites the model's audience to embrace a new 'reality' – one that casts both the present and the future in a fresh light and can lend newfound clarity.

In the literature, despite their importance, countermodels remain largely overlooked as a concept. In the recently published *Handbook of the Philosophy of Scientific Modelling* (Knuuttila et al., 2024), for example, countermodels are almost entirely absent across its 40 chapters, leaving the concept largely unexplored.

This gap limits our analytical understanding of countermodelling, including how they operate, what they reveal, and why they matter socially and politically. Seen as interventions, countermodels are deliberately designed to disrupt the narrative constructed by mainstream modelling and challenge how authority and legitimacy are distributed. They operate to shift the boundaries of debate, question assumptions, and highlight what is missed.

The interventionist aspect of countermodelling foregrounds the performative nature of modelling. By presenting alternative framings, countermodels reconfigure how water systems are understood and what futures are seen as desirable. They challenge who gets to define the terms of the debate and who makes visible the contingency and partiality embedded in mainstream modelling. Analytically, this positions countermodelling not as a form of neutral critique aimed at falsifying hydrological assumptions or model structures, but rather as a framework for situated intervention in political and epistemic struggles to demarcate claims to authority and legitimacy.

While the term countermodelling is not explicitly used, examples embodying its core dynamics appear throughout the literature. Lane et al. (2011), for example, examine the performative aspect of flood risk modelling in the UK, showing how models are shaped by a managerial logic that prioritises closure, accountability and predictability, at the expense of complexity and justice. They explain how mainstream modelling enacts futures that are aligned with policy, financial and managerial goals, limiting ambiguity through cost – benefit calculations. They argue for alternative modelling approaches that are open to challenge, especially by incorporating non-expert perspectives[1].

[1] A more detailed example of countermodelling that involves non-experts and empowers grassroots movements can be found in de Souza et al. (2025), which discusses the emancipatory nature of countermapping in river struggles in Ecuador.

Conditions and strategies

To build countermodels, the modeller draws on a range of strategies. These include adopting different epistemic approaches, incorporating alternative value frameworks, and tweaking the modelling boundaries to include neglected voices, experiences and/or socio-ecological dynamics. Such moves allow countermodels to operate with different priorities and assumptions, thereby redefining what counts as common sense or the common good in relation to a given issue.

De Souza et al. (2025) show how grassroots actors foreground Indigenous worldviews to reject top-down irrigation plans, recasting rivers as living relations rather than extractable resources. In another case, they document how countermapping enabled communities to bring environmental harms that had been omitted from official maps, into the open. These efforts challenge dominant narratives, making space for more diverse forms of knowledge and voices.

In yet another example, Godinez-Madrigal et al. (2020) challenge the Zapotillo Dam project in Mexico by reintroducing the effects of climate change and future demand variables into the official scenarios. By then comparing the results using the same performance indicators as the mainstream models, they questioned the project's assumptions under more realistic conditions and revealed how earlier modelling had reflected the interests of only one side of the conflict.

These strategies unfold in politically charged conditions where power asymmetries limit dialogue between involved parties and where modelling has already been used to marginalise certain voices or foreclose seeing 'otherwise'. Unlike joint modelling initiatives (for example, the IPCC or the Joint Water Management Programs between riparian states), countermodels are not typically designed as 'tools for collaboration', but rather as 'tools of resistance' that challenge mainstream portrayals of water realities and expose biases, often in defense of justice.

While effective in raising alternative claims, countermodels can also increase polarisation unless they are mediated through legal or institutional review. Examples of this can be found in transboundary water conflicts where state-commissioned models serve primarily as diplomatic leverage. Bolivia's 2018 filing of a 'counter-memorial' to the International Court of Justice (ICJ, 2018) challenged Chile's claims over the Silala River. Bolivia argued that a century-old channelisation of the river's headwaters in 1928 had increased water flow to Chile and that this warranted compensation. Chile's response, however, was to downplay the impact and reject Bolivia's claim.

As Wheater et al. (2024) note, the Bolivian and Chilean models differed in scope, assumptions and data treatment. The Bolivian models estimated that channelisation had increased flow by 31 to 40%, while Chile's countermodels suggested that the impact was under 1 to 3%. Their strategy mainly involved improving the stability of the Bolivian models, correcting inconsistencies between scenarios and, most importantly, placing greater emphasis on providing a comprehensive understanding of the river's hydrogeological conditions.

Often missing from such disputes is a deeper examination of how modelling is thought about, how models are made, how information generated by them is communicated, and how all these intersect with social expectations, imaginaries and inequalities. Such an examination would allow for an understanding of a model's legitimacy, not only in epistemic terms but also in how it is constructed through negotiations in courts, scientific institutions, and public and policy spaces. The next section explores these dynamics through the case study of the Zayandeh-Rood River.

THE CASE OF THE ZAYANDEH-ROOD WATER CONFLICT

The Zayandeh-Rood, the largest river in central Iran, has been vital for centuries due to its location and symbolic value. It breathes life into the city of Isfahan, which was the capital of Persia in the 16th and 17th centuries.

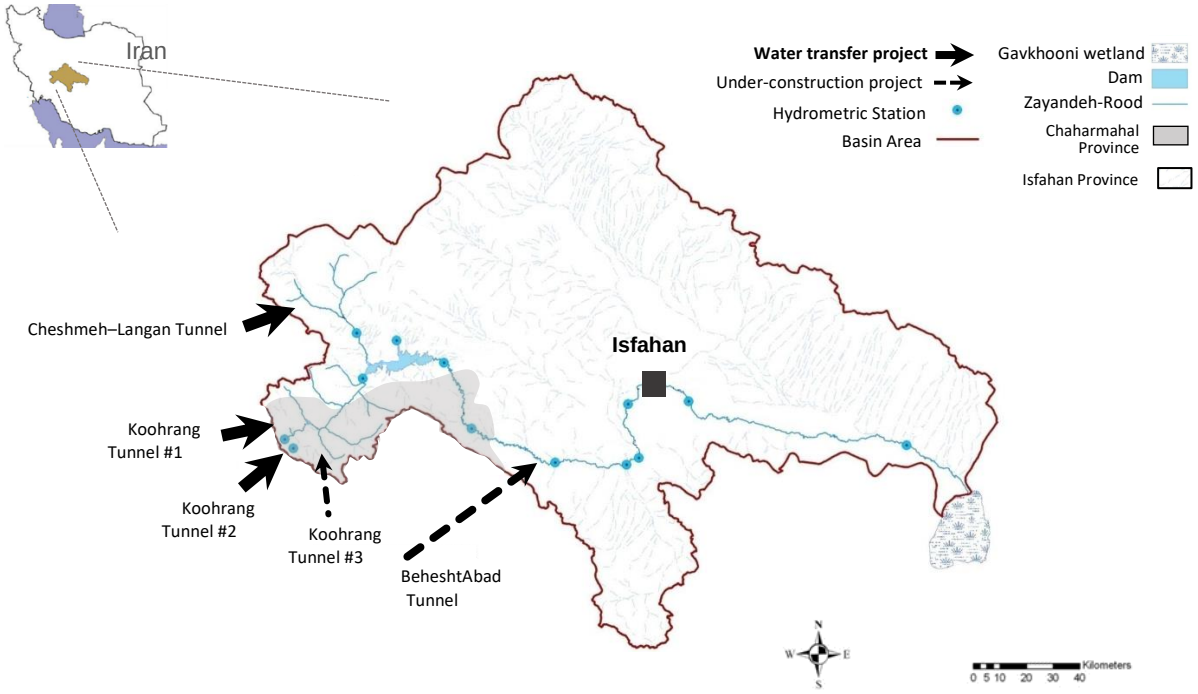
Unregulated water abstraction, water-intensive agriculture and industry, weak governance, limited public participation, and shortcomings in water laws have severely strained the river basin, pushing it to a critical state (Nabavi, 2017a, 2018). This was exacerbated by two major drought periods. The first of these was between 1998 and 2001, during which the river's supply of water to Isfahan dried up for the first time since the construction of the Chadegan Dam in the late 1960s. The second drought began in 2007 and has persisted in the years since, causing significant social and environmental challenges.

The river's average flow has decreased by 1 million cubic metres/year (Mm^3/year) (Saedi et al., 2021), meaning that most years it is dry before it reaches Isfahan (through which it once flowed). It also no longer reaches the Gavkhooni Wetland at its tail; this both disrupts the ecosystem that depends heavily on the river's water and violates Iran's obligations under the Ramsar Convention.

Shared between the provinces of Isfahan and Chaharmahal-Bakhtiari (hereafter Chaharmahal), policymakers in each province blame the other for the ongoing issues. The blame is particularly directed at unauthorised pump installations in the upstream Chaharmahal and at water-intensive practices such as rice farming in unsuitable areas, outdated agricultural methods, and water-intensive industries such as steel production and oil refining in downstream Isfahan (Nabavi, 2017b). Both sides express their frustration over the other side's lack of transparency in reporting its true water consumption figures and water needs. This mutual distrust further complicates collaboration among policymakers and experts, slowing efforts on necessary activities such as data-sharing and joint modelling (Hatami and Norbakhsh, 2019; Golkarami and Kaviani, 2017).

In this context, models and modellers gained greater importance as they began to shape ongoing debates. Models were used to analyse the basin's current conditions, predict future scenarios, and evaluate policy options. Simulations also began to be developed, mostly by academics, to explore the connections between water resources and socio-economic factors, generating what-if scenarios to guide decision-making.

Figure 1. Zayandeh-Rood River Basin in central Iran.



Note: Arrows indicate water transfer projects; the grey area represents the political territory of the upstream province of Chaharmahal.

In the following section, we examine how models and calculations are deeply entangled with broader sociopolitical dynamics through complex, nonlinear co-production processes. Drawing on empirical research, the paper highlights the active, interventionist role of modelling in reconfiguring the water conflict.

The discussion below is of course not intended to undermine the validity or necessity of modelling for water management in the region; rather, it draws attention to how, in Iran's Zayandeh-Rood River Basin, modelling (and countermodelling) have become part of a complex web of interactions that shape how the neighbouring provinces make sense of the present and imagine their water futures.

METHODOLOGY

The Zayandeh-Rood River Basin was selected as a critical case for this research due to its status as one of the most conflict-ridden water basins in Iran, and also because of its extensive modelling activity and its central role in national water policy debates. The basin is home to Iran's most iconic river and is a key site where competing water claims across provinces, sectors and scales are debated through numbers and calculations as well as political rhetoric. As such, the Zayandeh-Rood provides a rich context for examining how modelling both reflects and shapes sociopolitical dynamics in contentious water settings.

Data for this research was collected through extensive ethnographic fieldwork in the basin. This included 64 in-depth semi-structured interviews with key regional and national informants such as NGO activists, academics, farmers, water experts, and national and regional water authorities (56 interviews from the Zayandeh-Rood region). Public perceptions of the basin were primarily explored through 29 in-depth interviews with Isfahani residents and with tourists travelling by train to or from the city of Isfahan; these comprised over 60 hours of recorded conversations. The train setting facilitated informal yet substantive discussions about the river, its significance, and perceptions of its present and future conditions. The analysis also draws on data gathered through a participatory engagement (Pathways Theatre) with 40 stakeholders (Nabavi, 2022b). Interviewees and participants were selected on the basis of their active involvement in basin-related issues, particularly in relation to the controversy surrounding the BeheshtAbad Water Transfer Project. This paper also benefits from an ongoing project by the author on the oral history of water modelling in Zayandeh-Rood, which includes interviews with modellers in the basin. These interviews have not yet been publicly released. In line with concerns raised by ter Horst et al. (2023), this paper minimises the use of direct quotations to protect the identities of specific individuals, given the relatively small number of experts working on this issue and the sensitivity of the topic.

The analysis was further triangulated through participant observation, documentation of how actors enacted their positions, and the examination of material and discursive artifacts such as public protests and social media interactions, all of which were treated here as ethnographic data. The Pathways Theatre exercise (Nabavi, 2022b) was used as a focused ethnographic site that exposed power dynamics as stakeholders performed conflicts (beyond verbal accounts). The researcher's long-term embeddedness in the basin's social networks offered valuable access to informal conversations and behind-the-scenes insights that enriched the analysis.

This study does not provide a detailed technical analysis of the models nor an assessment of their epistemic validity, as these aspects are outside the scope of the current research.

ANALYSIS OF THE CASE STUDY

Although the case of BeheshtAbad is not short of research, the studies remain fragmented and no comprehensive review has been conducted (for an early attempt to address this gap, see Alipour et al., 2024). This limits opportunities for critical engagement and allows for the selective use of knowledge in

shaping policy agendas, thus opening the door to decision-making that serves certain interests and narratives.

That said, the existing body of research reflects a growing awareness of the challenges associated with BeheshtAbad. These challenges include: technical issues such as tunnel water inflows, karst-related leakage, and blasting risks; social and economic impacts such as increased migration, disrupted livelihoods, and rising living costs; political tensions ranging from inter-regional disputes and ethnic conflicts to security concerns over infrastructure; and environmental effects such as groundwater depletion, drying springs, and reduced water availability during droughts (see Babaei Shahraki et al., 2013; Davoodi Dehaghaani and Ameri, 2019; Zaki and Rashidi, 2016; Mohamadi et al., 2019; Ghoreishi et al., 2019; Madani and Mariño, 2009; Tavakoli Nabavi, 2011). These and other studies have destabilised the idea that BeheshtAbad is backed by scientific consensus, which has made it harder for policymakers in Isfahan to claim technical authority in justifying the project, as they initially did (see below).

Building on this, that section explores how water modelling in the Zayandeh-Rood River Basin becomes a focal point where there is a convergence of water expertise, political priorities, societal expectations, and historical narratives. I first examine: 1) how the initial calculations produced by the project's consultants were deeply entwined with the region's long-standing imaginary of water transfer, and 2) how this contributed to legitimising its construction. I then briefly outline how this was contested by countermodelling efforts, and use a co-productionist lens to explore how modelling affords the making (and unmaking) of water realities. The final section returns to modelling as an intervention technology, offering further insights into its co-productive nature.

Modelling becomes the focal point

The 400-year-old imaginary of water transfer

The severe droughts of the early 2000s, which dried up the river for the first time in years, pushed water authorities to consider large-scale transfers from the Karoon River. This urgency grew after a second major drought in 2007, leading to the active promotion of the BeheshtAbad project as a solution to the region's deepening water crisis.

The Karoon River originates in Chaharmahal and flows through Khuzestan to the Persian Gulf. The BeheshtAbad project aimed to transfer water from the Karoon to Iran's Central Plateau – including the cities of Isfahan, Yazd and Kerman – an arid but politically influential regions that was facing rising water demands. In 2008, despite objections from the Department of Environment, the Iranian Parliament approved the project, which was also supported by the Iranian Water Resources Management Organisation. The Ministry of Energy tasked regional water companies with transferring 1100 Mm^3 through a 67km tunnel, 300 metres underground, and building a 1800 Mm^3 reservoir, thus making it the largest water transfer plan in the Middle East (Abrishamchi and Tajrishi, 2005; Morid, 2003; Zayand-Ab, 2008).

BeheshtAbad was expected to revive the Zayandeh-Rood and meet the region's growing water demands. Isfahan authorities pursued the project, while blaming upstream Chaharmahal for "illegal" water withdrawals that had dried the river; this especially affected farmers in east Isfahan, which the river no longer reached (Mohammadrezaei, 2022). Upstream actors pushed back, however, seeing it as a convenient excuse to cover Isfahan's own water mismanagement.

Water transfers from the Karoon River have long been central to Isfahan's approach to addressing water scarcity. Since the 16th century, water governance in the city and the region has been tied to political authority and social order, with rulers managing distribution (Khaneiki, 2020). European travellers have documented Isfahan's long-standing desire to divert water to sustain growth (see below).

This imaginary was realised in the 1950s when Gibb and Partners, a British civil engineering firm, finally brought this "centuries-old dream"[2] to life with funding from Iran's government and local leaders. The Koohrang water transfer project, later featured on Iran's 50 rial banknotes, became a symbol of modernisation and local development. It increased the flow of the river by approximately 40%, adding 340 Mm^3/year to a natural flow of about 900 Mm^3/year. This volume was later regulated with the completion of the Chadegan reservoir, which has a capacity of 1500 Mm^3 (Molle et al., 2009). The region was thereby transformed into a hub for irrigation, water-intensive industries, and increased employment opportunities.

After the 1979 revolution, however, agriculture and industry expanded even more rapidly. This placed an unsustainable burden on the river and, despite the increased flow from Koohrang, the river now fails to reach its tail at the Gavkhooni Wetland. The community of Isfahani farmers, who once supported the original Koohrang project, have now been left waiting in vain for water. In response, two additional Koohrang tunnels (Koohrang #2 and #3) have been constructed, adding another 500 Mm^3/year, and in 2009, the Cheshmeh-Langan tunnel was also built to divert 200 Mm^3/year from the Dez River to the Zayandeh-Rood (Molle et al., 2009).

BeheshtAbad is the final and largest project in this series. It drew strong support in Isfahan, but faced fierce resistance from upstream Chaharmahal and also from Khuzestan Province, through which the Karoon flows. Actors warned of severe environmental harm from BeheshtAbad and accused Isfahan of over-reliance on supply-side solutions. They urged Isfahan, as the province controlling 90% of the Zayandeh-Rood Basin, to improve its local water governance.

Legitimising the imaginary

The BeheshtAbad project and its initial calculations were developed by experts from the Isfahan Water Authority well before the droughts in Isfahan. It was not until the droughts intensified, however, that the project gained traction and was presented as "the solution" to Isfahan's water crisis. During this time, a 12-year feasibility study led by an Isfahani water consultant became central to media and public debates, providing the scientific grounding (Zayand-Ab, 2008).

This study is often cited in policy circles and public debates as the "scientific rationale" behind the project. The narrative around it often frames opposition to the project as a rejection of science itself. In the media, people often heard statements like, "If the water transfer project is cancelled, it would mean that the 12 years of scientific study would go to waste" (*MehrNews*, 2014). Water policymakers also emphasised that the study was not merely a biased analysis by Isfahani experts, but rather that it was a collaborative effort involving top international water specialists and that it had undergone rigorous peer reviews and independent verification. In an interview, the project's lead, for example, highlighted the scientific foundation of the BeheshtAbad water transfer, saying that,

> [BeheshtAbad] has been studied and designed with the participation of a reputable consultant with international experience from France and a prominent domestic consultant in accordance with technical standards. The study results underwent rigorous scrutiny in provincial committees and the Ministry of Energy, and were further reassessed by an Austrian company (…), confirming the findings of the initial approved studies.

As regional debates intensify, a key question dominates discussions: What are the consequences of not pursuing the water transfer? The majority of research highlights that the water transfer is 'essential' for the sustainability of Isfahan. This perspective is captured in the title of a paper by a trusted and leading hydrologist in Isfahan, *Water Transfer to the Zayandeh-Rood River Basin: A Choice or a Necessity* (Safavi, 2012). Presenting detailed tables of calculations and numerical analyses, the paper argues that,

[2] It was thus described by Sir Clarmont Skrine in his address to the Royal Central Asian Society on "New Trends in Iran".

"transferring water to the Zayandeh-Rood River Basin is essential (…) and remains the only viable option for water managers and policymakers". This sense of inevitability is further echoed by a key activist, a university professor in Isfahan:

> Water transfer projects are like surgery to treat a pain for which there is no other method of improvement (…), the solution is to supply water, meaning the implementation of water transfer projects, to prevent Gavkhooni wetland and agricultural lands from dying, as they will become sources of toxic and polluted dust particles damaging Isfahan city and public health (…)] The implementation of the BeheshtAbad water transfer projects is inevitable.

Other studies also warn that failing to act quickly and allowing the river to remain dry could lead to severe sustainability challenges for the city and its fragile regional ecosystem, with far-reaching social, psychological, health, environmental and economic consequences (see, for example, Sarvari et al., 2019; Taghipour Ziksari and Rafifar, 2023; Javadinejad, 2016; Mohamadi et al., 2022). Some researchers offer a different perspective, however, suggesting that, according to their models the water transfer may not be a sustainable solution and that, in fact, in the long run it could backfire (see Madani and Mariño, 2009; Tavakoli Nabavi, 2011). They argue that water consumption in the basin will quickly catch up with the increased supply, thus being an example of a basin for which "enough is never enough" (Molle, 2008).

Modelling has become central to public and political debates on the river crisis, elevating both the status of models and the visibility of those who produce them. Water experts – consultants and academics alike – now find themselves in high-stakes, politically charged contexts, where their models shape and are shaped by public controversy. Their models and calculations no longer remain behind the scenes; they now "take the stage" (Hilgartner, 2000) in government and parliamentary discussions, actively driving decisions and influencing debates. Conferences, panel discussions, and thematic symposiums have further reinforced this shift, becoming key venues where the legitimacy of the water transfer is actively constructed.

This heightened visibility intersects with cultural narratives that frame the river's fate as not just an environmental issue, but a matter of collective identity and moral urgency. In 2011, the Zayandeh-Rood River was added to Iran's list of natural heritage sites, a symbolic move that framed the river not just as a waterway but as a shared identity and historical legacy. Tapping into this emotional connection, advocates of the water transfer have advanced a compelling narrative: that transferring water is not only necessary but inevitable to preserve both the river and the community's sense of self. Such narratives, while powerful, tend to obscure the inherent uncertainties and assumptions embedded in the modelling process, that is ranging from boundary choices and recovery estimates to aquifer characterisations and projections of recharge and yield (Molle, 2008).

A clear example of this entanglement between modelling and sociopolitical values can be seen at the first National Conference on Zayandeh-Rood Sustainability in Isfahan. Framed around the goal of "harnessing the nation's scientific capabilities to restore the perennial flow of the Zayandeh-Rood River", the event opened with a resonant message from local authorities: "Without Zayandeh-Rood, there would be no Isfahan" (Ranjbar, 2013). This sentiment was repeated in subsequent conferences and echoed by local interviewees, who expressed a deep spiritual connection to the river. As one person put it: "Zayandeh-Rood is like a mother to us (…) without it, Isfahan becomes a desert, and everyone will have no choice but to leave".

Field observations showed that conferences, workshops and symposiums functioned primarily as sites of sociotechnical negotiation and legitimacy construction for the water transfer project. This was materialised through technical presentations, planned discussions and curated moments of consensus, which ultimately contributed to the naturalisation of water transfer as the inevitable solution to the region's water scarcity. It was a solution that aligned with both the centuries-old imaginary of interbasin transfer and the prevailing technocratic ethos of Iran's national water governance (Nabavi, 2022c).

Far from serving as inclusive platforms for discussion and deliberation, these events in downstream locations resulted in a shared conviction that, 'Isfahan's situation is unsustainable'. This conviction, tightly bound to a sense of urgency and inevitability (Nabavi, 2016), helped frame water transfer as a moral imperative for the common good. These framings also aligned with the financial and political interests of actors who were advocating for the rapid completion of the BeheshtAbad project.

These conferences, all supported by local authorities, also served to depoliticise the water crisis by framing the problem of Zayandeh-Rood as one that required only technical input from the "water engineering epistemic community" (Nabavi, 2022c). As a member of the Water Committee of the Isfahan Chamber of Commerce stated, "The Beheshtabad is the result of 12 years of expert work and should not be changed or questioned based on non-expert opinions", and he urged "universities across Isfahan province to prioritise research and studies focused on restoring the Zayandeh-Rood" (IRNA, 2014). Within this narrative, water experts and modellers were positioned as the ones who could 'save' the river without any need for public deliberation and participation (see, for example, Khabar Farsi, 2014).

Public discussion around the water transfer became even more securitised following the violent confrontations on 28 February 2013, when Isfahani farmers, frustrated by the government's failure to address water supply issues, clashed with special police forces. This incident marked the start of a decade-long cycle of protest in Isfahan, with further developments as recently as March 2025. The increasing securitisation of the issue has further narrowed the space for debate and civic engagement (for a more detailed account of the protests in Isfahan, see Amini and Azari, 2023).

Countermodelling as resistance

Defending 'the other river'

The securitisation of discussion around water transfer was so intense that water experts from upstream authorities and research institutions often found 'freethought' was nearly impossible, as one modeller put it. Reflecting on the first conference on interbasin water transfer in 2003 in Tehran, one of the region's water modellers recalled how presenting their accepted papers seemed nearly impossible due to the overwhelming tension around the topic. These modellers were specifically tasked by local water authorities in Khuzestan to travel to the capital and present their papers at the conference to "defend the [Karoon] river's water". As one interviewee described it,

> The atmosphere at the conference was incredibly tense. Questioning interbasin water transfer felt like insulting something sacred (…). During the conference, a loud noise suddenly erupted. There was an argument, and then we went to see what happened. A large number of reporters from Khuzestan Province [the province through which the Karoon River flows] came, but they weren't allowed in. They started chanting and pushing at the door. The door was broken, and chaos ensued at the conference entrance (…). I heard later that when the organising team noticed the articles [and discussions] were taking a different direction, they didn't want media coverage. (…) later, we realised that the conference was organised (…) to justify the BeheshtAbad and to advance Isfahan's projects.

A few years later, as the BeheshtAbad proposal gained momentum in public and policy discourse, upstream modellers challenged its feasibility. They argued that the original study relied on oversimplified assumptions about upstream conditions and failed to account for long-term impacts on the fragile ecosystem and water quality. This risk, they asserted, could severely affect the 60% of the upstream population that was reliant on the so-called 'surplus' water identified by downstream calculations.

To address this, upstream modellers began using scenario-making to present alternative perspectives that they believed had been overlooked in Isfahan's calculations (see, for example, SaeediNia et al., 2008; Samadi-Boroujeni, 2010, 2012; Samadi-Boroujeni and Saeedinia, 2013). By introducing different model structures, variables and datasets, they not only challenged the credibility of the tunnel's feasibility study but also highlighted the significant negative consequences of water transfers on the upstream regions.

They focused particularly on the Karoon basin which was intended to supply the water, showing how such transfers could threaten its long-term stability.

A Water Evaluation and Planning (WEAP) model developed by water modeller academics in Chaharmahal challenged the project on its hydrological feasibility and its scale (SaeediNia et al., 2008; Samadi-Boroujeni and Saeedinia, 2013). By redefining the model's boundaries to better reflect upstream conditions (including all major water projects and their demands), the model showed that the amount of transferable water in the BeheshtAbad project averaged around 470 Mm^3/year but is limited to 314 Mm^3/year with 90% reliability, which is 46% less than downstream calculations of available water. The model also challenged the proposed 1800 Mm^3 reservoir storage, calling it an "overestimate" and suggesting that no more than 600 Mm^3 was actually needed. The pushback could have gone even further. As one modeller recalled, upstream water policymakers had initially expected that the model would show "zero" availability for transfer, believing that all available water was needed to first meet their own demands.

The Chaharmahal model ultimately became influential. Its results circulated among regional and national policy circles and triggered investigations by Iran's General Inspection Office and the Supreme Audit Court. Reflecting on their countermodelling strategy, the modelling team noted:

> They [Isfahan] hadn't used any of the data we did. Their work was purely hydrological—they collected some data, took averages, created tables, and concluded that the mean flow was a certain value. Based on that, they estimated 1.5 billion cubic meters of available water. Then they claimed 300 million cubic meters would go to the [Koohrang] Third Tunnel, and 1.25 billion to BeheshtAbad [tunnel]. The environmental flow for the downstream river was supposedly covered by local springs. There was no mention of Khuzestan [Karoon River] at all.

This was just one of several efforts to challenge the dominant narrative around water transfer. That same year, a report by the Iranian Parliament Research Center brought national attention to the BeheshtAbad project. It criticised the project for lacking a comprehensive social, environmental and economic assessment, warning that, "the situation [in the basin] will be exacerbated" even if the transfer goes ahead (Arab and Samani, 2008). The report drew heavily on research from upstream modellers and water experts, many of whom had long-standing concerns about upstream impacts and strong ties to Khuzestan water authorities. The report helped shift the issue into broader policy debates, this time with greater support for the upstream perspectives on the issue.

Supporting this shift, system dynamics models developed by water researchers showed that BeheshtAbad would not resolve the Zayandeh-Rood's water challenges in the long run. Instead, the models warned that it would drive increased downstream demand, deepen reliance on supply-side solutions, and lock the basin into repeated water transfers (Tavakoli Nabavi, 2011; Madani and Mariño, 2009; Nabavi et al., 2017).

The resistance narrative further drew on global frameworks, particularly UNESCO's criteria on interbasin water transfer (1999), which was frequently cited in interviews and in the parliamentary report. This positioned BeheshtAbad as a project that violates international norms, with serious concerns about its unreliable environmental assessments, sociocultural disruption, and unfair distribution of economic benefits.

Over time, debates increasingly aligned with Chaharmahal's position, led predominantly by academic water modellers. By presenting their findings at national policy forums and conferences, they forged new scientific authority for their province. This enhanced authority legitimised Chaharmahal's voice in the debate and reframed its resistance as a reasoned, science-based call for justice (not an anti-development stance). Their growing influence of the modellers eventually led them to senior leadership roles within Chaharmahal's water authority.

A sociotechnical effort

Resistance to the BeheshtAbad project was not confined to the offices of upstream policymakers and modellers; rather, it evolved into a sociotechnical effort where knowledge production, community voices and political activism converged. Countermodelling thus became more than a technical exercise; it turned into a political programme that questioned the water transfer's ethical foundations and legitimacy. At the heart of this effort was a push to redefine what counts as common sense, the common good, and legitimate responses to managing shared water resources (see next section).

As new knowledge from water experts spread through society, it was 'bundled' with other stories and narratives that sought to undermine the project's technical legitimacy. This is clearly reflected in the title of a widely circulated statement by an influential upstream environmental activist, "BeheshtAbad Water Transfer Project Fails Technical Test". As the statement says,

> Of course, besides the technical problems of this project, the damages caused by BeheshtAbad across environmental, economic, and social sectors have been emphasised by the Research Center of the Iranian Parliament [see Arab and Samani (2008)](…). However, it seems that the power and interests of [Isfahan's] water authorities have outweighed all environmental and technical considerations. This is why we see budget allocations and the sale of participation bonds to push this project forward; and the warnings to prevent the exacerbating water crisis in Chaharmahal and the greater Karoon basin in Khuzestan have gone unheeded! Khakpour (2012)

This growing frustration soon spilled beyond technical discussions, fuelling a broader social and political movement in Chaharmahal and Khuzestan Provinces. For them, the project simply did not make sense. It conflicted with their lived experiences, values and understandings of the common good. As one Khuzestan representative in the Iranian Parliament put it,

> Should we leave one province thirsty just to satisfy another? What kind of *common sense* is that? (…). The water shortage, drinking water problems in towns and villages, and thousands of other environmental issues in Khuzestan all come from [previous] transferring Karoon's water. Is that really for the *common good*? Nouri (2016; emphasis added)

In response to the national government's failure to stop water transfers from the Karoon's headwaters, 18 representatives from Khuzestan Province resigned from Iran's parliament (Elyasi, 2013). In Chaharmahal, communities organised street protests, forming human chains that stretched for kilometres, staging marches, and blocking roads. These protesters identified themselves as "victims of the water mafia" and called BeheshtAbad "cursed" and a "red line"; they described it as the "symbol of Chaharmahal's death". They voiced deep distrust of local water authorities, who they feared were "under Isfahan's control", and demanded the "dismissal of officials who defend Isfahan's interests" (Rakhshan, 2021).

Collectively, these responses showed that resistance to BeheshtAbad was not resistance simply to the numbers generated by models and calculations, but also to what those numbers represented, which confirmed their deep-seated concerns about justice, identity and power.

Ultimately, the resistance efforts were powerful enough to successfully challenge Isfahan's claims that, 1) a large volume of water could be transferred without major consequences, and 2) that such a transfer would bring socio-economic benefits to the region. As a result, the BeheshtAbad project was revised from an underground tunnel to a water pipeline, with the transfer volume reduced to 760 Mm^3/year. Of this, 540 Mm^3/year was allocated for use, with the remainder reserved as an environmental purpose. For many upstream activists, however, this change still fell short of their demands to resist what they saw as downstream hegemony over the region. As one of their environmental activists put it, "We oppose the very essence of the BeheshtAbad water transfer, not just the way it's delivered or its volume".

The making of water realities

To offer a more detailed account of the co-production of modelling and sociopolitical dynamics in the Zayandeh-Rood River Basin, this section focuses on three interconnected spaces where models are emerging into and intervening in the 'making of water realities': the common resource, the common sense, and the common good. What follows unpacks these dynamic sites of interaction and their role in the ongoing making and remaking of the basin's water futures.

Making the common resource: 'Making' water and making it disappear

Water models are not built to just represent water; they 'make' it in a particular way. They intervene in the portrayal of a shared common resource, turning it into an object of governance, prediction and control; they influence policies, infrastructure (Nabavi and Daniell, 2017), and even how we define scarcity and surplus to align with particular priorities.

As seen in the case of Zayandeh-Rood, the assumptions and simplifications embedded in downstream models labelled the water in the neighbouring Karoon River Basin as 'surplus', which justified its redirection through interbasin transfer. A binary was created whereby the water was portrayed as being either 'wasted' – left to drain into the Persian Gulf – or diverted to serve the "needs of people suffering from drought". As discussed earlier, however, neither the demand nor the proposed solution is new. For centuries, the imaginary of water transfer has persisted as a way of remaking a new water reality for Isfahan. As the 17th century French traveller Tavernier recorded during his visit, the vision of diverting water from the Karoon River to the Zayandeh-Rood was seen as a way to remake Isfahan, transforming it into "one of the most fertile and pleasant lands on Earth" (Tavernier, 1957).

From this view, it can be argued that the water that is 'made' through modelling under the category of 'surplus' does not just show the existence and flow of H_2O in the hydrological sense; it also embodies a flow of history that has been centuries in the making. Countermodels can, and did, challenge the legitimacy of the claimed water surplus, however, by offering alternative quantifications and exposing the assumptions behind what determined the volume of water available for transfer. In doing so, they made the claimed water surplus 'disappear', turning it into a mirage that dissolves when subjected to a different set of concerns, data and scenarios. It could thus be said that models made water and countermodels made it disappear.

The shift from modelling to countermodelling in this case, however, is not merely epistemic. It is also a contest over legitimacy, where models do not simply provide calculation but also performatively construct realities whose authority depends on their alignment with political, social and institutional interests (Jasanoff, 1990; MacKenzie, 2008). In effect, one model's legitimacy can be undone by the logic and alignment of another; for example, while one model may prioritise the environmental sustainability of Zayandeh-Rood and the economic growth of Isfahan, another may focus solely on the long-term ecological health of the donor river, Karoon. These competing models reflect distinct realities (Krueger and Alba, 2022), each of which is grounded in different priorities, risks and values. In the process, they determine what becomes accepted as the 'right way' to manage resources that are held in common among stakeholders.

In effect, models *construct* the 'common-ness' of the shared resource, providing particular representations of water reality. They can thus play a role in reconfiguring water conflicts by offering particular ways in which water is understood, measured and managed as a common resource. In the case of Zayandeh-Rood, this has led to a contest over legitimacy as each model formulates its own version of scarcity, surplus and sustainability, with specific implications for how the shared resource is to be claimed.

This tension also reveals something more fundamental, which is that water, as it is represented in the models, is not a pre-existing resource waiting to be discovered; rather, it is a fluid and plastic thing that appears and disappears depending on the model's logic and its alignment with broader institutional and

political priorities. Much of this modelling work – and the tensions it generated – unfolded behind closed doors in the offices of water experts and on computer screens, that is, largely removed from public view or participation. When it did enter the public space, the debate was often reduced to binary choices, with definitive answers expected only from water experts. Examples of these binaries include: Which basin suffers most from drought, Zayandeh-Rood or Karoon? Whose environmental sustainability truly matters, upstream or downstream? And, further to that, is it the fading Zayandeh-Rood River and the dying Gavkhooni Wetland downstream in Isfahan that matters most, or is it the Karoon River, struggling to make its way to the Persian Gulf but burdened by dams and depletion before it even reaches the city of Ahvaz?

Making the common sense

Water models are key to how societies *make sense* of water systems and of life in the basin. By distilling complexity into clear, digestible insights, they provide predictions and solutions that are grounded in science. It is through the logic of the models and their alignment with societal expectations, priorities and values that their outcomes are perceived and potentially accepted by policymakers and the public as 'logical' or 'commonsensical'.

The common sense, like water, is shaped by the landscape though which it flows, that is, a cultural and historical terrain that is formed by shared beliefs, values and lived experiences that are unique to each place (see Marková, 2024). As found in this research, this landscape shapes common sense in two main ways: 1) through collective understandings that are rooted in social imaginaries and narratives that circulate within society; and 2) through practical reasoning, especially the shared causal beliefs that are held and promoted by epistemic communities.

The first of these pathways is evident in how water issues are framed within public discourse and cultural imagination. In Isfahan, for example, the Zayandeh-Rood River has long been portrayed as suffering from chronic water scarcity that could be 'fixed' through transferring water from elsewhere. As discussed earlier, the idea of an interbasin water transfer from the Karoon River has been in circulation for centuries as an 'ideal' solution to regional development. Over time, this narrative became deeply embedded in local imaginaries, gradually solidifying into a common-sense response to scarcity.

This framing gains further legitimacy when calculations indicate a perceived surplus in the Karoon River or when cost – benefit analyses show that the project not only makes hydrological sense but is also economically sensible. This, in turn, drives a co-production process that reinforces the imaginary of water transfer as the reasonable solution – so much so that opposing it risks being seen as impractical or even irresponsible, especially given the urgent water crisis faced by the basin. In the mainstream model, this co-production is accomplished by: 1) downplaying the social and environmental risks of water transfer for upstream areas by promoting the assumption that diverting large amounts of water from the Karoon River would not harm the ecosystem because natural springs would adequately meet environmental needs (SaeediNia et al., 2008); and 2) largely erasing past failures of water transfer projects from the conversation (Tavakoli Nabavi, 2011).

The second way in which common sense is shaped – that is, through practical reasoning and shared causal beliefs – plays out mainly through the water engineering epistemic community (Nabavi, 2022c), which holds significant control over the country's water governance. Workshops, conferences, blog posts, interviews and research publications become key spaces where engineers and academics challenge each other's claims and promote their causal beliefs, in this way shaping what is accepted as logical and reasonable in the eyes of each side of the conflict. Trusted figures such as university professors hold significant influence over public opinion and policy decisions, often positioning themselves as champions of 'science and justice' and as defenders of the community's right to water. They do so through a blend of data-driven arguments, appeals to social justice, political critiques, and symbolic rhetoric (see, for example, the open letter debates between Salavati and Ghomshi, 2014).

The hegemony of water engineering and the marginalisation of other epistemic communities – particularly those from the social sciences and local communities – has produced a form of common sense in the region that places little or no value on public deliberation and participation. It frames the water crisis as a problem of "mismanagement" (see, for example, Ghazi, 2025) that can potentially be resolved by handing the basin over to "better experts" who, by default, are often those with technocratic views and ideas (Nabavi, 2017a, 2018).

Making the common good

Science, as a public good, drives societal progress by advancing knowledge; in doing so, it contributes to the common good by providing insights and solutions to complex challenges. This common good, however, is both value-laden and contextual.

The first way in which this is true is that, models play a crucial role in defining and negotiating the meaning of the common good. With this in mind, Saltelli et al. (2020a) emphasise the responsibility of modellers to ensure that their models serve society and respond to its needs. No single model can meet all purposes, however, and the assumptions, data inputs and methods that shape these models influence which outcomes are prioritised, how uncertainties are framed, and which groups benefit from them. Being central to shaping the common good, models continually negotiate what that 'good' entails – be it environmental sustainability, economic growth, or social well-being. This process involves a diverse set of actors, including modellers, policymakers, communities and technologies; each of these brings distinct interests and values to the co-construction of the common good, which is a concept that is contingent and remains open to negotiation among those involved with diverse values and interests. Yet this very process can raise ethical concerns about how models may misuse their epistemic authority (Saltelli, 2025).

Second, beyond their value-laden nature, models – and the common good they help define – are deeply contextual. Different sociopolitical and geographical settings influence what is seen as the common good. As Jasanoff (2004) argues, societies draw on unique historical narratives, institutional frameworks and knowledge systems to legitimise expertise and shape collective futures. This means that models influence not just what is considered to be a problem worth solving, but also whose expertise is trusted, which values are prioritised, and what counts as a desirable outcome.

This dynamic is clear in politically charged conflicts like Zayandeh-Rood, where water models are part and parcel of shaping each side's vision of the common good. The calculations that were made by downstream experts, for example, were aimed at contributing to Zayandeh-Rood's environmental sustainability and the region's long-term social stability; at the same time, countermodelling becomes arrow and bow in the hands of upstream water experts whose goal is to safeguard the common good of their own community. The latter defend the donor river, the Karoon, which they believe is at risk of becoming the victim of yet another large-scale water transfer.

In this context, modellers become actors who blend scientific expertise with political authority. Their technical knowledge grants them credibility, which they leverage to occupy strategic positions within water governance institutions and even provincial leadership, placing water experts at the centre of political decision-making. The power structure in downstream Isfahan, for example, was influenced by the appointment to the governorship of Isfahan Province (2013-2017) of an expert from there who had held high-ranking roles (Deputy Minister of Energy for Water Affairs, chair of national committees on dams and irrigation). There continues to be a push to appoint a water expert as Governor of Isfahan, as shown by ongoing media campaigns (see, for example, Olian, 2024).

Together, these examples highlight the performative aspect of water expertise (including modelling) in shaping governance across the basin, where such expertise becomes a key resource for political leverage, allowing for the shaping of social and political realities in ways that benefit one side or the other.

The 'common' in common good thus becomes a site of contestation, one that must be continuously negotiated among diverse actors. What one community frames as sustainability may be seen by another as unsustainable; ecological protection for some may require economic sacrifice for others; and long-term planning for some may look like short-term extraction to others.

Caught in the middle of such tensions, modellers must navigate these complex social and political landscapes. The findings show that key water experts and modellers in the basin are strongly motivated by a sense of social responsibility. This commitment was often shaped by a personal or institutional vision of the common good, combined with a strong belief in the power of quantification to advance that vision. Similar efforts to promote the common good can be found in other fields and regions such as the French "statactivists" who use statistics to challenge official narratives and reshape public debates (Bruno et al., 2014).

The upstream modellers have translated their sense of responsibility to support the common good into a commitment to 'defend' the donor river and the communities that rely on it. By developing countermodelling, they were able to intervene in political debates, surface silenced impacts, reclaim their community's water rights, and challenge claims made by the mainstream models. When successful – as in the case of questioning the BeheshtAbad project – their countermodelling could delegitimise dominant narratives that supported water transfers, undo decisions based on them, or at least hold them in limbo. In such moments, the model's outputs redraw the lines between 'us' and 'them', establishing new boundaries of legitimacy. The idea of the common good 'stretches' to include their needs and concerns alongside those of others who share the resources.

This kind of boundary work, however, can come at a cost. Producing numbers that challenge dominant narratives is more than a technical exercise; it is also a political act. As one modeller described it, the work can feel like "swimming against the tide", carrying the risk of job loss and living in constant fear, fully aware that "the consequences and public backlash could be severe". Modelling under such conditions is more than testing hypotheses, as models carry not only numbers, equations and parameters, but also the weight of people's hopes and fears. They shape decisions about who controls water, who gains access, and who is left behind.

The co-produced intervention

Understanding the model as an intervention technology requires situating modelling (and countermodelling) within the broader sociopolitical dynamics in which they operate. Drawing on a co-productionist approach and the material discussed in previous sections, it is clear that models are not singular agents that can shape water conflicts on their own, nor does their influence come only from their technical content. Instead, their authority and impact are co-produced through how they are enacted in specific situations such as public and policy spaces, institutional uptake and support, and the framing work done by experts and policymakers.

The initial modelling by the consultants was adopted by Isfahan's water authorities as the mainstream calculations. While various socio-environmental studies have questioned the legitimacy of BeheshtAbad (see, for example, Davoodi Dehaghaani and Ameri, 2019; Zaki and Rashidi, 2016; Mohamadi et al., 2019; SaeediNia et al., 2008; Samadi-Boroujeni and Saeedinia, 2013), the project continues to be regarded as a viable and necessary option for Isfahan.

This was partly due to the framing efforts of water experts and policymakers in Isfahan, but also because of a long-standing imaginary of water transfer that is deeply embedded in the region's history. The 'surplus' water generated through the calculations should thus not be seen only through the lens of hydrological or cost – benefit analyses. Instead, it should be understood as a co-produced entity that is socially desirable (reflecting long-standing historical imaginaries), environmentally impactful (aimed at restoring the river and the Gavkhooni Wetland), and politically strategic (addressing social unrest and supporting regional economic growth).

Framing BeheshtAbad as essential to the sustainability of the Zayandeh-Rood helped consolidate epistemic authority around the project. This framing afforded particular ways of seeing: who qualifies as a legitimate stakeholder, what counts as valid water knowledge, and how the river's hydrological system is understood – all of which aligned with and reinforced Isfahan's interests. The Zayandeh-Rood has thus been made a self-contained hydrological unit, managed by Isfahan; it requires minimal civic engagement and, in some ways, is detached from the Karoon River. This understanding positions actors in Isfahan as the river's primary and legitimate stakeholders, on whose terms the water in BeheshtAbad can be categorised as 'surplus' and 'available for diversion'.

This framing, however, faced strong sociotechnical resistance from upstream provinces. In Chaharmahal and Khuzestan, local actors rejected any models and calculations that called for even partial sacrifices of water from their regions to benefit Isfahan or the wider Central Plateau. Such models were widely seen as strategic distortions that framed fairness and sustainability in ways that legitimised Isfahan's hegemony over them.

It is also important to emphasise that the model's influence cannot be separated from the agency of its human interlocutors, who perform crucial work that legitimises the model's role in public and policy spaces. This dynamic was particularly evident in how expertise and politics became closely intertwined; modellers took on senior roles in provincial governance, actively engaged in public and policy discussions, and organised regional/national conferences to be covered by media to influence public opinion. These practices allowed them to simultaneously demarcate water knowledge and authority (Wynne, 1992; Jasanoff, 2004), shaping not only hydrological understandings of the basin but also the political decisions about it.

The research shows that modelling and countermodelling were not there simply to support or reject BeheshtAbad per se. They came into being to help create certain sociopolitical realities amid the competing water futures that exist within the conflict. As sociologists studying unrest in the region have concluded, "In Isfahan, Chaharmahal, and Khuzestan, where water conflict is unfolding, a social movement is also taking shape – one in which power is being renegotiated to shape the future" (Amini and Azari, 2023). This movement, as far as this research can tell, is not confined to one side; rather, it is reshaping how people across the region make sense of the water crisis in their everyday lives. It particularly influences what counts as common sense and the common good in relation to the common resources on which these communities in central Iran and its fragile ecosystems depend.

CONCLUSION

While it is often assumed that the world of modelling and calculation is separate and untouched by politics, the case of Zayandeh-Rood shows otherwise as does an increasing body of research in the water domain. There is growing consensus that the politics involved in modelling has non-epistemic explanations, mostly stemming from the practical choices made throughout the modelling cycle (Melsen, 2022; Melsen et al., 2019). These choices, however, are closely entangled with broader social and political dynamics, as STS research particularly argues (Jasanoff, 1990; Latour, 1987; Pinch and Bijker, 1984).

This paper adopts a sociotechnical lens, viewing modelling not as just number-crunching machinery, but as an intervention technology that embodies the hopes, fears, values and expectations of those who build and use them. In contentious water conflicts, modelling in particular becomes a focal point where expertise, political interests and societal priorities continuously interact and reshape one another.

The controversy around the water transfer project in the Zayandeh-Rood River Basin is used as an example of such a critical site, where modelling and countermodelling emerge as sociotechnical interventions that are deeply entangled with competing visions and understandings of the common resource, common sense, and common good. Using the co-production framework (Jasanoff, 2004), this paper examined how these dynamics unfold in practice.

Highlighting the performative aspect of water models, the paper shows how modelling efforts can embed, reinforce or challenge particular assumptions, ideas and worldviews that influence water conflicts, and how they are, in turn, shaped by them. In the case of BeheshtAbad, for example, models that framed upstream water as 'surplus' reinforced a vision of sustainability that is rooted in the centralised development and historical imaginaries that are tied to downstream Isfahan. At the same time, countermodelling efforts challenged this by introducing alternative scenarios and narratives to highlight equity and environmental integrity across the entire basin.

Acknowledging the social embeddedness and performative aspects of modelling is not an argument for radical relativism where 'nothing is real'; rather, it recognises that modellers interpret and characterise water reality through the lens of their institutional settings, technical infrastructures, and normative commitments. As such, the performative aspects must be examined in relation to the societal norms, dominant narratives, and power structures that shape modelling practices and outcomes.

Today, nearly all major water projects claim to be grounded in robust modelling of their environmental, social and economic impacts. These models are often presented as objective and authoritative. As this paper has argued, however, whether models are used to support or contest a project, they play a central role in mediating the relationship between science and society and thus in shaping decisions and power dynamics.

Future research should examine how models produce specific social and political effects in contested water contexts and how these effects, in turn, shape modelling. This underscores the need for greater focus within hydropolitics research, particularly given the critical role of modelling in water diplomacy and conflict resolution across many transboundary rivers worldwide. Such studies can provide valuable insights into the co-production of modelling and hydropolitics, while also raising important questions about responsibility in these settings. Questions can include: What responsibilities are held by modellers and the broader modelling ecosystem? How should these responsibilities be distributed across the diverse actors and networks that make up this ecosystem? And how can modelling be used to support participation and deliberation, rather than rendering them redundant as was the case in Zayandeh-Rood?

Engaging seriously with these questions is critical if modelling is to contribute to more just and sustainable outcomes. This is particularly true in high-stakes contexts like water conflicts, where facts are contested and competing realities must be negotiated through modelling and countermodelling.

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