Hydropowering sustainability transformation: policy frames on river use and restoration in Finland

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Hydropower, as a flexible energy source, has sparked renewed interest in the ongoing decarbonisation of the society. Simultaneously, a wider transformation of the socio-ecological system towards more sustainable practices of energy production is required. Our paper draws from the sustainable transformation theory and the concepts of transformability, hydro-social cycle, and aquatic regime to study a system of water governance and regulation in Finland. Our case study data consists of 16 semi-structured interviews and 207 news articles from Yle national broadcast company. We studied the policy frames to reveal how the water governance actors understand, view and make sense of future river use and restoration, and how they utilise the frames for strategic purposes. Results demonstrate that the future river use and restoration were framed by four modes of thinking: 1) hydropower as a 'cultural trauma', 2) restoring rivers and dam removal after hydropower construction and operation to improve ecological flows in rivers, 3) improving the social acceptance of hydropower and dam removal, and 4) improving the efficiency of the hydropower regime as a flexible source of power. Our paper shows that to enable pathways for socio-ecological-technical transformations of aquatic ecosystems further scientific scrutiny should be focused on reconciliation of the interest of river restoration, recreational uses of aquatic environments and the flexible energy function of hydropower in energy transition. Removal of migration barriers and small-scale hydropower plants and building fishways and bypasses are part of this transformation. Furthermore, the river regulation needed to give impoundment facilities the flexibility, causes changes in water levels which may be a potential source of conflict between riparian residents and hydropower operators. Therefore, more emphasis should be placed on water governance that recognises the local dynamics and interactions within the social-ecological systems.

Keywords: sustainability transformation, frame analysis, river restoration, hydropower

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Introduction

In environmental law and governance, hydropower development clashes with biodiversity targets and water quality objectives of the EU's (European Union) Water Framework Directive, and the conflict is well documented (Wieringa & Morton 1996; Ziv *et al*. 2012; Abazaij 2015; Lees *et al*. 2016; Barbarossa *et al*. 2020; Wang *et al*. 2021). The construction, operation, and maintenance of hydroelectric dams entail trade-offs against sustainable development objectives, for while power plants provide electricity and contribute to overall development, they decrease ecological connectivity and damage biodiversity, cultural values and local livelihoods (Zarfl *et al*. 2015; Halbe *et al*. 2018; Schneider *et al*. 2019; Soininen *et al*. 2019). The carbon neutrality targets set in the Paris Agreement art. 5 call for rapid reduction of fossil fuels in the energy system. Diffusing renewable energy sources, such as wind power, contribute renewable electricity but also increase the intermittency of power generation. Such measures affect hydropower as part of the solution to stabilise the electricity system by providing flexibility; on the other hand, hydropower has faced heavy criticism because of the ecological damage and negative local social impacts it causes (Abazaj 2015; Moran *et al*. 2018).

Thus, despite the benefits in advancing the transition towards a low-carbon society, hydroelectricity is an ambivalent energy source. On the one hand, the need for clean and affordable energy globally has resulted in an increase in hydropower projects, especially in the Global South (Zarfl *et al*. 2015). On the other, in the Global North, the removal of dams to free and restore rivers has been seen as a way to return rivers' ecological functions (Lejon *et al*. 2009; O'Connor *et al*. 2015; Bellmore *et al*. 2017; Chaffin & Gosnell 2017). This partially reflects the decreased relative importance of hydropower in the electricity generation mix (e.g. Soininen *et al*. 2019), while at the same time highlighting a regime shift towards cultural valuation of the post-industrial roles of rivers as recreational resources and better functioning ecosystems. Recently, the international science panels on climate change and biodiversity – the IPCC (Intergovernmental Panel on Climate Change) and IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) – issued a report demanding closer attention to climate and biodiversity interactions that have been overlooked in transformative policies (Pörtner *et al*. 2021). This has led to the emergence of experimentation with adaptive responses that provide in situ solutions to identified conflicts. For example, in Finland, river ecosystem restoration requires unprecedented adaptivity from hydropower production to better acknowledge other values of rivers. However, the Finnish environmental planning system (e.g. granting of water permits) has a proven degree of maladaptivity, rooted in technology-driven governance (Soininen *et al*. 2019).

The governance of aquatic resources in Finland has leaned heavily towards allocating the maximum amount of available water for hydropower production of electricity (Belinskij & Soininen 2017). Hydropower was a high political priority in the country after the World War II and was supported by an alliance of both industry and politicians, as it boosted regional development and electrification of the country (Myllyntaus 1991; Pokka 1991; Alaniska 2013). As the demand for electricity increased over the years, interpretations of the 1902 Act, and political pressure to pass legislation deviating from its strict rules, increased accordingly (Myllyntaus 2002). Before the 1930s, the Water Rights Act (31/1902) favoured fisheries over power and prohibited the building of large-scale hydropower dams that would have blocked the entire fairway of the river. In the beginning of the 1930s a great recession, and by the end of the decade World War II led to the introduction of ad hoc legislation that established far-reaching exemptions to the 1902 Water Rights Act (Myllyntaus 1991; Pokka 1991). The Finnish Parliament passed legislation that allowed urgent permitting of certain damming and regulation projects and relaxed the criteria and procedural safeguards for granting permits to hydropower operations. The standard criterion for permits after the legal changes was that the societal benefits of hydropower operation had to outweigh the harms. And they did, almost without exception. This consideration was enshrined in the law with the passing of the Water Act in 1961 (264/1961) and is in operation still today (Belinskij & Soininen 2017; Iho *et al*. 2022).

More recently, the environmental regulation has imposed strict limits on the expansion of hydropower and stringent criteria in the review of existing permits. Article 4 of the Water Framework Directive (WFD) sets the objective of achieving good ecological status of European waters and promotes the non-deterioration principle, two aims that are difficult to reconcile with hydropower

production (Abazaj *et al*. 2016; Feichtinger & Pregernig 2016). Moreover, the WFD (art. 11) requires a periodical review of existing permits. In Finland the hydropower capacity can only be increased in rivers with existing hydropower plants, as most of the rivers have already been built for hydropower generation and the remaining free-flowing rivers are legally protected (Soininen *et al*. 2019; Similä *et al*. 2021). The main thrust of the WFD is thus the review of existing permits, and the Directive is part of a regulatory setting that has started to shift the focus of governance actions from the management of aquatic resources to the restoration and rewilding of rivers (Polizzi *et al*. 2015; Lehtoranta *et al*. 2017; Oksanen *et al*. 2020).

We argue that the socio-ecological trade-offs and discursive contestations are connected to different heuristics of change employed by the actors (e.g. Feola 2015). The societal debates and knowledge conflicts regarding sustainability of localised socio-ecological conditions of rivers are connected and studied in relation to wider socio-technological views of water governance regime transformation (Pahl-Wostl *et al*. 2010; Hordijk *et al*. 2014; Patterson *et al*. 2017). To bridge the epistemic challenges of different transformation heuristics, we turn from a political ecology focus on the underpinning spatiotemporal developments and power relations towards actors' positions in framing the sustainability challenges (e.g. Lawhon & Murphy 2012). The trade-offs in the level of societal development (e.g. pathways to achieving a low-carbon society) and land-use planning (e.g. addressing ecological restoration in specific river basins) are closely connected to the perspectives and interests of diverse societal actors who are either tied to or challenge the dominant aquatic regimes (Bavinck & Gupta 2014; Mustonen & Lehtinen 2021). The actors that participate in the meaning-making and knowledge conflicts use discursive framing of political issues and specific societal challenges that require further scrutinising and prioritising (Bjärstig *et al*. 2022). Significantly, the frames exclude certain challenges and may become mutually exclusive, further polarising the societal dialogues.

In this paper, we apply frame analysis to study how the water governance actors understand, view and make sense of the future sustainability of river use and restoration in Finland. The analysis enables the exploration of policy frames in expert talk and in news media, which can present the issue at hand as either neutral or politically contested (e.g. Rosenbloom *et al*. 2016). This approach opens views on disentangling multiple developments in the national policy sphere, cultural orientations towards water bodies, technical development of diverse future solutions and locally politicised issues. Our research focuses on a time when the calls for river restoration are increasing while the position of hydropower in the energy system remains strong, signalling a potential shift in the current hydro-social cycle (e.g. Swyngedouw 2004). Essentially, we ask: What is the status of the sustainability transformation in the hydropower sector? How are river use and restoration framed in expert talk and news media in Finland?

The remainder of the article consists of four sections. In the following section, we turn to the transition perspective embedded in the socio-ecological dynamics of water governance. After that, we explain the data and methods and embark on the frame analysis, which reveals the perceptions and sense making of the water governance actors and news media. Finally, we discuss our findings and put forward conclusions and the insights gained.

Transformation dynamics in hydropower governance: applying the lens of contested aquatic regimes

Over the last decade, the sustainability transition literature has struggled to better engage with geographically embedded ecological and social challenges related to change (Truffer *et al*. 2015; Calvert *et al*. 2019; Köhler *et al*. 2019). Some headway can be made by drawing from the water governance literature which is geographically embedded and conceptualises water in terms of river basins or catchments, which are often characterised as complex adaptive systems with emergent social-ecological properties, feedbacks and path dependencies (Chaffin 2014; Feola 2015; Akamani 2016; Pahl-Wostl 2020). Several scholars have characterised and identified conditions and requirements for socio-technical, social-ecological, and governance changes that enable river basins as social-ecological entities to maintain their core functions under change (Folke *et al*. 2002; Gunderson *et al*.

2002; Meadowcroft 2011; O'Brien 2011; Frantzeskaki *et al*. 2016; Pahl-Wostl 2020). However, the water governance literature lacks a nuanced, empirically reasoned, understanding of intentional change towards more sustainable systemic conditions inscribed into transformation heuristics. Moreover, the socio-spatial embedding of sustainability, which concerns specific places, as well as the trans-scalar nature of the environmental issues and issues of power regarding whose interests are advanced and whose are threatened in the transformation processes, have remained blind spots in transition scholarship (Truffer *et al*. 2015).

Three concepts bridging this gap are of value in this study. First, we build on the concept of **transformability**, which refers to system characteristics enabling new social-ecological pathways and transformational change (Walker *et al*. 2004; Chapin *et al*. 2009; Folke *et al*. 2010). Transformations can occur spontaneously or deliberately, in which case they pursue a particular goal (e.g. good ecological status of waters) (Folke *et al*. 2010; O'Brien 2011); and are often triggered by crises or regime shifts sparked by an environmental conflict or litigation over the use of natural resources or environmental change (O'Brien 2011; Cosens *et al*. 2014). On the other hand, legal and governance systems are established to provide predictability over time and to maintain stability in society (Cosens & Gunderson 2018, 12; Wenta & McDonald 2019). Although stability is a component necessary to ensure the functioning of an energy system, it might hinder emergent socio-ecological developments towards sustainability.

Second, the **hydro-social cycle** comprises the political ecologies of water through which water is produced, made known, and directed to specific uses (Swyngedouw 2004; Linton & Budds 2014). Swyngedouw (2015) has studied how authoritarian governments, such as Franco's regime in Spain, harnessed rivers for development to bring the country into hydro-modernity. Similarly, taming and harnessing hydrological systems to serve electrification and advance modernisation projects have been mainstream practice in more democratically governed societies. A careful tracking of shifts in sustainability and participation in a hydrological and social realm can offer ways to rethink socio-ecological transformations towards more sustainable systems (Swyngedouw *et al*. 2002).

Third, the concept of **aquatic regime** takes in the water ecosystem of the river basin and the flow-altering governance system attached to it (Bavinck & Gupta 2014; Mustonen & Lehtinen 2021). The concept originates from the notion of flow regime in aquatic ecology, which captures how hydropower alters river flow and ecological connectivity (Bunn & Arthington 2002; Mustonen & Lehtinen 2021). Yet aquatic regimes can also be conceptualised from the perspective of transformation, as social-ecological systems are not in any permanent states but rather move through phases that are connected to societal values, demands and uses of specific hydrological landscapes.

We approach these concepts as means to understand different transformation dynamics at play in the Finnish public debate on river restoration and the future of hydropower with respect to its social, ecological and economic impacts (see Fig. 1). The hydro-social cycle embraces the temporal aspect of transformations and changing social valuation in defining the role of water. For its part, the dominant aquatic regime presents a set of practices historically connected to management of water bodies in diverse planning contexts. In the political framing of river use and restoration, public discourses and actor positions become central in promoting and challenging alternative aquatic regimes with different socio-technical and socio-ecological practices related to flow-management (e.g. Rosenbloom *et al*. 2016; Bjärstig *et al*. 2022). In this light, we suggest that political framing of hydropower can be best captured using both concepts; this approach will enable us to understand the interplay between and within contradictory aquatic regimes, which in turn leads towards shifts in hydro-social cycles and transformations of aquatic regimes. Furthermore, the interplay of aquatic regimes potentially increases transformability of the system – and thus goes beyond the discursive exchange to yield tangible outcomes. For sustainability transitions (e.g. Geels & Schot 2007; Turnheim *et al*. 2015), the frames can reveal the diversity of future pathways and keep actors mindful of the need for solutions to persistent environmental challenges. Moreover, the societal frames emphasise the political and normative nature of the regulatory arrangements underlying the established and alternative energy transition trajectories (Pinker *et al*. 2020).

Our frame analysis sought to understand differing perceptions and meaning-making of the water governance actors. Framing is an analytic process that is used to make sense of public issues or

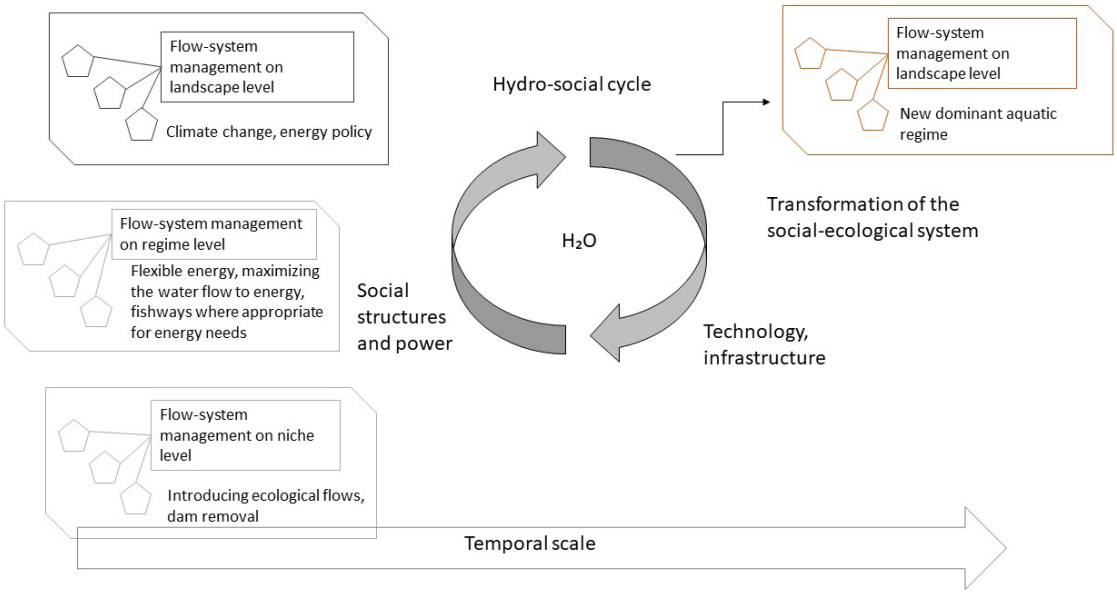

Fig. 1. Conceptual understanding of transformation through hydro-social cycles and aquatic regimes.

perceived reality in a way that promotes the salience of a particular problem definition, interpretation and suggested solution (Entman 1993; Hansen 2015; van Hulst & Yanow 2016). Framing has been conceptualised as having an institutional or cultural origin (Goffman 1974; Schön & Rein 1994) or as the active selection of frames in which actors choose and defend policy positions by selecting what is relevant to the issue and what is not (Entman 1993; Ryan *et al*. 2001). Although these two views have been described as reflecting two separate schools of thoughts (Lindahl *et al*. 2016), in our analysis framing river restoration and hydropower appears to be rooted in institutional positions and cultural values that may be actively chosen to support policy positions and the frames evolve over space and time. We draw on the concept of place-related, put forward by Lindahl and colleagues (2016), inasmuch as water governance involves a material dimension of water travelling through the hydrological cycle. This requires an open and dynamic understanding of places (Massey 1997) as social relations within socio-ecological systems. Framing is also connected to the making of energy landscapes by building on and (re-)producing multiple ecological, social and political scales (Calvert *et al*. 2019; da Silva & Hussein 2019). Frames evolve over space and time, as socio-ecological systems are in continuous change, that is, water availability or flood frequency may vary (Chapin *et al*. 2009, 12).

Frames have been defined as interpretive lenses that derive from institutionalised narratives that guide political action and combine meanings, metaphors, and images (Schön & Rein 1994; van Hulst & Yanow 2016). In policy controversies, frames are developed for strategic purposes as they reflect policy positions, also called policy frames (e.g. Fischer & Forester 1993; Tynkkynen 2010; van Hulst & Yanow 2016; Dekker 2017). Compared to policy frames, which are actively communicated by policy actors to support a particular position, news frames are often taken for granted, presenting a packaged world (Gamson 1985, 618; Hansen 2015). Yet these journalistic frames do not develop in isolation: they incorporate political and cultural values and are constituted by multiple social actors, including corporate powers, the political elite and social movements (Ryan *et al*. 2001). Frames might evolve or lose their explanatory power over time once issues became politicised and de-politicised. Actors might also absorb frames from each other, and in the transitional context, technological solutions and socio-ecological preconditions might change.

Case study on hydropower in Finland

Expert interviews and news articles

The case study data consist of 16 expert interviews and 207 news articles. Case study research can combine multiple sources of data and methods and is therefore suitable for research orientations which aim at comprehensive understanding of the transitional process and policy issue at hand (Yin 2009). We contacted water governance actors in order to collect empirical evidence on the policy framings of the hydropower debate. The participants for this study were selected based on their expert status (see Table 1 for identifiers and descriptions) and represent a wide range of professional backgrounds, encompassing actors from the hydropower industry, public administration and NGOs. The interviews, semi-structured in format, were conducted in March and April in 2021 via Microsoft Teams communications software. All interviews were recorded and transcribed. The transcribed interviews and news material from Yle national broadcasting company were imported to Atlas.ti software, enabling the qualitative coding of the interviews.

Table 1. List of interviews according to institutional status and the values and interests they represent.

Group	Identifier	Values and interests
Industry	Int1	Economic orientation, flexible power, collaboration
Industry	Int2	Economic orientation, flexible power, collaboration
NGOs	Int3	Ecological orientation, river restoration, good ecological status of waters
Administration	Int4	Planning orientation, local planning, choosing effective measures, removal of small-scale hydropower
Administration	Int5	Planning orientation, local planning, choosing effective measures, removal of small-scale hydropower
Industry	Int6	Economic orientation, flexible power, collaboration
Industry	Int7	Economic orientation, flexible power, collaboration
Industry	Int8	Economic orientation, flexible power, collaboration
Industry	Int9	Economic orientation, flexible power, collaboration
Administration	Int10	Planning orientation, local planning, choosing effective measures, removal of small-scale hydropower
Administration	Int11	Planning orientation, sins of the past, local planning, choosing effective measures, removal of small-scale hydropower
Industry	Int12	Economic orientation, flexible power, collaboration
Administration	Int13	Perspective on the administrative court system
Administration	Int14	Ecological orientation, river restoration, good ecological status of waters
Administration	Int15	Planning orientation, local planning, choosing effective measures, removal of small-scale hydropower
NGOs	Int16	Ecological orientation, river restoration, returning migratory fish, good ecological status of waters

To explore framing of hydropower debate in public media, news material on hydropower was collected from the web news of Yle, the national broadcasting company, between 2017 and 2021 (see Table 2). These years were selected because of the increasing public debate in the Finnish news media calling for improving the ecological condition of and restoring rivers. Since the Weser-ruling, Case C-461/13 *Bund v Germany* [2015] ECR I-433 ('*Bund*'), after which the WFD objectives have been legally binding in keeping to the non-deterioration principle (Paloniitty 2016), governments in EU member states have taken more action to restore river basins. The Finnish government introduced a river restoration funding programme for the years 2020 to 2022, *Nousu* (Ministry of Agriculture and Forestry 2022), which funds river restoration projects, with measures including dam removal and building fishways.

Table 2. News articles from Yle.

Year	News articles (n = 207)
2021	51
2020	43
2019	43
2018	29
2017	46

Frame analysis

Our analysis began with a content analysis, which formed the basis for the frame analysis (Goffman 1974; van Hulst & Yanow 2016). We focused on ecological, social and economic impacts of hydropower and the transitional aspects that might support or hinder river restoration and removal of small-scale dams and hydropower plants. When the interviews were coded, we divided the text excerpts into 11 groups, with 166 codes. After this, we distinguished three institutional groups, creating a unique dataset for each to enhance the comparison of the different frames.

Next, we coded the 207 news articles from 2017–2021 and classified them based on topic. Our examination of this five-year period revealed the shift in interest, noted above, from building fishways to the removal of dams and small-scale hydropower (see Fig. 2). When combining the analysis of these two datasets with the frame analysis methods (described in chapter 2), we distinguished four frames: 'cultural trauma', 'river restoration', 'social acceptance and recreation' and 'flexible power'. In the section that follows, we will turn to the framing the sustainability challenges underpinning the spatiotemporal developments and power relations towards the transformation heuristics.

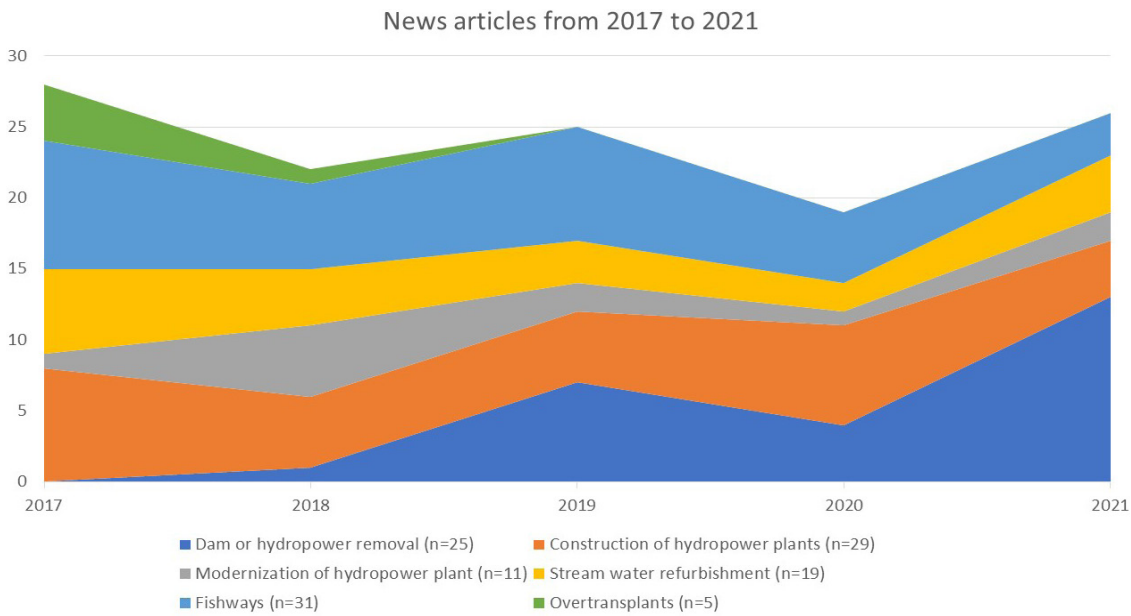

Fig. 2. News articles from 2017 to 2021 classified according to suggested water governance solutions.

Varying lenses on hydro-social regime – four frames of hydropower

Hydropower as a cultural trauma

Hydropower construction has caused a 'cultural trauma' due to the loss of migratory fish; for example salmon fishing on the Kemijoki River ceased with the building of hydropower (Alaniska 2013; Autti 2013). Arguments within this frame recognises the historical significance of the need for hydropower during the early twentieth century as well as the need to repair the damage done in the past: "The power plant harnessed one of the best salmon rivers in Europe. The Kemi River of the past disappeared but the dream of the return of the salmon and the trauma of the loss of the river remain." (Yle 6.11.2019). This frame was pronounced in the interviews, especially that with the environmental non-governmental organisations (eNGOs) and environmental administration, and in the news material, which more often reported on the restoration projects than on the environmental conflicts. One of the interviewees commented:

> [...] I think hydropower construction in the past happened under acceptable circumstances, but this also caused big losses. Valuable migratory fish stocks were lost, and migration paths cut, spawning areas ruined and now it's high time to remedy those mistakes and it's expensive and long-term work to do so. [...] (Int5)

One key factor linking the current considerations of ecological flows to the past is the strong permanence of hydropower permits (Soininen *et al*. 2019). Within this frame, the calls for revising the current Finnish Water Act (587/2011) were welcomed, as many hoped that a revision would make it easier to introduce a range of ecological compensation measures; these are still lacking in many older permits, especially those granted for smaller hydropower plants, that is, ones with a capacity of less than 5 MW (e.g. Kosunen & Mikkola 2017, 126).

River restoration

The methods proposed for restoring riverine ecosystems and fish stocks were numerous, with these including dam removal, fish ladders, natural bypass streams, a novel 'fish elevator' and fish stocking. Within this frame, the actors often equated compensation measures with fish ladders, even when the discussion was not remotely about them. This confounding of the two could at least partly be explained by the media attention that technical fishways have received and the fact that returning ecological flows might not be cost-effective in every context. However, the costs of building fish ladders in Finland are rising, in some cases significantly, from the initial estimates (Koljonen *et al*. 2021, 32). One industry representative commented on this in the following way:

> [...] Public discussion has drilled into people the idea that a fish ladder is the way forward. [...] A fishway doesn't solve everything. I do not think building a fish ladder at every power plant will make the world better. [...] (Int1)

Most interviewees stressed that regardless of how the costs are divided between public, private and citizens' organisations, measures should be planned and chosen for the specific local context. Most of the actors agreed with the need to take the local circumstances of each river basin into account. Representatives of administration and industry in particular considered it important that the authorities chose a measure due to its estimated positive impact in the specific setting, rather than searching for a 'one-size-fits-all' measure for all locations. This also applied to ecological flows: no single solution was suggested as superior to others. Especially interviewees in administration and NGOs emphasised the importance of restoring ecological flows. Natural bypasses were suggested by some interviewees, but only those from NGOs advocated them. Some of the actors pointed out that there is still uncertainty about how to design bypasses so that certain fish species can navigate their way through them, and that more research is needed. Some industry representatives also mentioned ecological flows as one option among many, emphasising the need for locally adapted solutions instead.

None of the actors, including those representing industry, opposed the removal of dams, which would be the most transformative approach to river restoration. The question was only about agreeing on the price:

> Good collaboration between stakeholders is in order to pinpoint locations with high nature values. That would be the key. And then providing the right tools for that. For example, paying a fair price and buying the area from its owners and then rewilding it. (Int6)

Dam removal is framed as a viable option in places where production values are low and current or potential nature values are high. None of the actors proposed removal of large dams, and some noted that dismantling such installations would be so costly, due to the high costs of compensation the operator, that such a course of action would not be worth pursuing. Hence, removal was seen as viable only for small-scale hydropower and dams that produce no electricity and serve no flood control purpose. The interviewees representing industry made the point that no measure should be pursued simply for its popularity; rather, the effectiveness of a measure or measures should be estimated before production capacity is sacrificed.

The news material featured the development of technical solutions as well as the political atmosphere relating to river restoration and returning migratory fish over time. Most of the articles on dam removal projects were published in 2021, with Hiitolanjoki being the project that figured most visibly, because it involved private investment in river restoration and a 20-year legal battle between the hydropower company and one local activist (Yle 5.10.2019, 1.8.2021). Under the headline "The endangered fish species has been given new hope" (Yle 30.11.2021), the news media highlighted arguments for dam removal due to its favourable impact on migratory fish, especially the endangered lake trout. Other topics covered included fishway and river restoration projects throughout the country, many of which had received government funding for piloting different techniques, such as fishways, fish ladders, fish elevators and fish transfers.

Social acceptance and recreation

The social acceptance of hydropower can be examined at different scales. Within this frame, ecological considerations were the primary factors impacting acceptability on a national scale. Favourable views might have been encouraged by environmental NGOs and other activists, as currently both traditional and social media discourses are focused on migratory fish. On a local scale, residents and summer homeowners along the river, the regulation of flow is of concern, as they are often the first groups to experience any short-term changes in flow. A representative of ELY-Centre noted:

> […] I know examples […] from northern Finland where the short-term changes in regulation are considered significant and it causes harm to other water usage and the people living along the river experience this. […] We also get contacts asking 'Can't you do something about this?' and once we determine the flow is within the permit parameters then there's barely anything we [the supervisory authority] can do about it. (Int4)

Overall, the chances of local communities and riparian residents of influencing hydropower projects were depicted as limited. Flow regulation requires the balancing of several conflicting interests, including generation of low-carbon electricity and profitability, the grid requirements between base and peak loads, recreational use of the waters, flood risk management and ecosystem needs. Industry representatives argued that collaborative efforts can minimise tensions relating to recreational use, exemplifying how the flow can be adjusted according to the needs of different events happening on a river that require a certain water level. Impact assessments of hydropower projects must consider social impacts. Riparian residents can appeal permit decisions, but such appeal processes are lengthy and require a knowledge of how to argue in administrative courts (Albrecht & Ratamäki 2016). Interviewees from industry mentioned that flow regulation is sometimes discussed and planned with locals, but that this is not a standardised practise. In addition, one representative commented that exploiting the flexibility of hydropower output and accommodating the increasing importance of recreational use of rivers poses challenges:

> […] summer cabin owners come even earlier […] and because of that […] adequate water level for recreation is even more important today. […] we've had to pay even more attention to ensure the lakes are at an adequate level for recreation. (Int7)

The news material stresses the importance of recreational values, and some of the river restoration projects were framed as improving the recreational value of the rivers concerned: "The aim of the river restoration is to enable fish migration and breeding and to improve the recreational use of the Touru River" (Yle 2.10.2018). These river restoration projects were often located in municipal areas and therefore in active recreational use. On the other hand, the most visible conflicts in the media centred on fisheries obligations and building more hydropower. Industry representatives in the north of Finland opposed stricter fisheries obligations, whereas other actors, NGOs such as the WWF (World Wildlife Fund) among them, demanded them (Yle 20.9.2017, 15.12.2017). The prospect of building more hydropower in the Kemi River basin has been a source of prolonged environmental conflict (Yle 22.5.2017, 31.10.2019). The proposed Sierilä power plant received an environmental permit but the project triggered a social movement (Yle 19.7.2019, 17.7.2020).

Flexible power

Considering that hydropower provides 15% to 25% of Finnish electricity and 45% of the renewable electricity production, hydropower remains an important part of the country's energy system (Official Statistics of Finland 2020). Several of those interviewed for this study considered it a necessity that has its place in the future energy mix, although ecologically harmful. In the news material, hydropower was framed as part of the Nordic energy markets. One reservation here is that the market price depends on weather conditions in rainy years, the price of energy overall is cheaper and during dry years it is higher. As one headline announced: "The hot summer dried up the hydropower and sent the wholesale price skyrocketing by 40 per cent" (Yle 4.1.2019). The main reason for this was hydropower's capacity to adjust output based on grid requirements. Other renewable energy sources, namely solar and wind, are intermittent, and hydropower production can flexibly be adjusted depending on the output of other energy sources and grid needs. This framing was predominant among industry representatives, as it was most common to emphasise hydropower's flexibility and profitability:

> I think that regarding the whole electricity market the significance of hydropower will grow due to its flexibility, so when more wind power is built, or maybe in the future solar power as well, which are both [...] weather dependent [...], this creates more need for flexible power generation [...] in the electricity market. (Int9)

The actors viewed the future of small and large hydropower plants differently. If the discussion centred on national hydropower output as a whole regardless of the size of the power plants, hydropower was mostly considered significant, especially for its flexibility. Representatives of small-scale hydropower producers pointed out that the smaller installations are profitable, since a plant's lifecycle is long, and even a run-of-the-river plant provides a mostly steady output. Hence, it can be economically significant to its owner:

> [...] if the production capacity is, say, under 100 MW then in that case, we can say it actually has some significance, but if you have a 1 MW plant then I think it has zero significance. It mainly has just economic significance to the project planner, and it's taken into consideration that way but otherwise it has no significance. (Int13)

Especially the industry's representatives but also interviewees in administration pointed out that hydropower plants, even small ones, provide municipalities real estate taxes, increasing their societal acceptance. However, most actors considered only large power plants to be of any national significance both now and in the future. However, industry representatives indicated that the public discussion and compensation measures that may be required in the future negatively impact small-scale hydropower generation in particular. Hence, it is too early to estimate if all small-scale hydropower will become unprofitable, but for low-carbon electricity generation to have enough pros to outweigh its ecological cons, the future as framed will undoubtedly bring challenges for small-scale hydropower in Finland.

Discussion – the socio-ecological trade-offs in contested hydro-social regimes

The ongoing societal focus on sustainability transformation has revealed socio-ecological trade-offs and policy mismatches in river use and restoration. In terms of hydro-social cycles, hydropower

remains strongly established in the Nordic energy system as a flexible power source that balances out what is increasingly variable electrical power from renewable sources. However, advocates of alternative uses and roles of river ecosystems have become more vocal, pointing towards the emergence of alternative and multiple aquatic regimes that vary territorially. This was also confirmed in the four frames – cultural trauma, river restoration, social acceptance and recreation, and flexible power – identified in our analysis. The diverging frames and perspectives on transition need to be considered across the policy contexts and spatiotemporal scales of water governance (da Silva & Hussein 2019). This requires overcoming epistemic challenges, uneven power relations (e.g. hydropower company and riverside residents), as well as legal and governance-related barriers, to ensure socio-ecological transformation towards sustainable use of rivers and its multiple benefits. Furthermore, the case challenges the capacity of established legislative frameworks to navigate the demands of current sustainability transitions (Pinker *et al*. 2020). Drawing on these insights and considerations, in what follows we put forward three syntheses that position the governance of hydropower in transition across territorial contexts.

First, over the past five years, the dominant aquatic regime of Finland has placed increasing emphasis on dam removal projects and returning ecological flows. According to our interviewees, river restoration, building fishways and migration barrier removals were spotlighted as a solution for improving the ecological condition of rivers required by the WFD. Some actors criticised the hydropower industry for favouring measures that allow them to retain as much of the river flow as possible for power generation. Overall, in the present case, the sustainability challenges were mostly framed as governance choices such as which measures and which type of collaboration to favour, and where. Some interviewees pointed out that the European Commission has expressed concern that the lack of compensatory measures in Finland for rivers where dams and hydropower are built could violate the country's obligations under the Water Framework Directive regarding ecological flows (EC 2015, 2019).

Second, dam removal projects are gaining momentum globally, especially in North America and Europe (Foley *et al*. 2017; Habel *et al*. 2020). Given this trend, hydropower in Finland should also be seen as case necessitating a balancing between the socio-ecological valuation and energy demands. Our findings suggest that within this context the removal of small hydropower plants and other small migration barriers is considered more feasible than the removal of large-scale plants with economic significance. According to our study, compensation based on the power plant's market value would markedly improve companies' willingness to remove dams. Significantly, the impacts of removal projects are reviewed, as the Water Act requires that they have a water permit (Similä *et al*. 2021). In addition, Habel and others (2020, 6) suggest that inputs of different actors should be considered in considering dam removals, with projects ideally including short-term and long-term scenarios anticipating the impacts of the removal. It is noteworthy that even in rapidly developing nations, such as China and Brazil, one sees a clash between the concern for ecological sustainability, the interests (viability) of local communities and the national interest in providing electricity have slowed hydropower development (Atkins & Hope 2021; Sun *et al*. 2021). Such tensions reflect questions of political, social, economic, and legal feasibility of dam removal projects (Patterson *et al*. 2021). If we are to consider sustainability transformations more rigorously in the hydro-social cycle, innovations in governance are sorely needed. These would enable societal inclusion, mobilisation of effective compensation measures, mapping of the legal landscape and clarification of the limits on river restoration. A more comprehensive governance would also encompass biodiversity impacts and potentials in the particular locations where dam removals take place.

Third, emphasis should be placed on reconciling the interests of recreational uses of rivers and the water management system. Many of the actors suggest that unpredictable fluctuations in flow regulation negatively impacts local acceptance of water governance actions, and thus residents' reactions to fluctuations in the flow need to be considered more carefully. Furthermore, many argued that collaboration between national, regional and local actors in planning and managing river restoration improves social acceptance. Regardless of which measures are used, and where, to reinstate ecological flows, it is likely that altering flows will affect water levels. An illustrative example is the proposed dam removal on the Sélune river in France, which has faced local opposition, including

from local politicians. Fuelling the opposition is 'a fear of the salmon', as some local fishers considered overt campaigning for restoration of the river as elitist, fearing the impacts the return of salmon would have on other local fish stocks that have prospered in the reservoirs (Germaine & Lespez 2017, 668). In our study, all actors were in favour of enabling the returning of salmon, although, depending on the framing, some recommended a stepwise approach in the process of allowing migratory fish to return to the rivers. Others suggested that dam removal alone is not sufficient to restore rivers' ecological condition, urging instead that habitats and environmental flows be restored at the river basin-level. These findings and considerations indicate that the including local communities in the planning of possible transformative changes to flow regimes would further recognition in water governance of the socio-ecological nature of the hydro-social cycles.

Finally, we would point towards the broader conceptual implications of the empirical lessons. The traumas of past energy transitions of harnessing hydropower to meet growing hydropower needs on the national scale have institutionalised the aquatic regime of modernity (Mustonen & Lehtinen 2021). The energy transition frame of hydropower as a necessary balancing component of the energy mix builds on that same regime, one that may overshadow more nuanced frames on hydropower as well as perspectives accommodating more systemic transformations (e.g. Geels & Schot 2007; Turnheim *et al*. 2015). Meanwhile, the views indicate that there are different takes on the matter and that more will emerge because they are territorially embedded. The varying valuation and the emergence of alternative aquatic regimes, where the territorially embedded socio-ecological transformations lie at the core of the knowledge claims (Feola 2015). The territorial and trans-scalar dimensions related to social and cultural aspects of energy have also been addressed through the concept of energyscape (Kaisti & Käkönen 2012; Howard *et al*. 2013; Lempinen 2019). However, the space for territorially embedded responses has to be enabled in the governance frameworks of the system-level energy transition. Hence, it is noteworthy how hydropower and river restoration were framed in the expert talk (e.g. as a sin of the past and large scale, whereby small-scale power plants could be removed) differed from the news media framings (e.g. reporting on floods or droughts and on licencing of hydropower projects or dam removal). Rather than intensifying this juxtaposition between different aquatic regimes, local and national scales or socio-technical transitions and socio-ecological transformations, we suggest that the focus be directed on environmental governance frameworks that might bridge the recurring discrepancies. In particular, the transformability of water governance and legislation systems can enhance the systemic capabilities of anticipatory navigation between different registers of societal valuation and establishment of adaptive policy measures (e.g. Walker *et al*. 2004; Folke *et al*. 2010).

Conclusions

In this paper we have explored the framing of the future sustainability of hydropower and river restoration in Finland. We explored which type of technological solutions are selected for restoring rivers and how they evolve over time. We studied the social acceptance of the water governance regime and the need to balance between ecological targets and hydropower as a flexible energy source. Our results, although scrutinising a water governance system in one national context, has wider implications for research on social-ecological systems, as our study reveals the policy frames reflecting the crucible in which the modes of power, multiple values and interests, multiple interpretations of policy problems, and preferred outcomes on river restoration hydropower projects.

According to our findings, more emphasis should be placed on water governance that recognises the variety of local social-ecological systems. Similarly, Heino and Koljonen (2022) argue that the policy instruments should recognise that river ecosystems are spatially and temporally dynamic meta-systems. This requires further thinking based squarely on the hydro-social cycle (Swyngedouw 2002; Linton & Budds 2014), as this makes it possible to steer the socio-ecological system towards better recognition of biodiversity, societal and cultural values and adaptation needs. However, striking a balance between socio-economic benefits and functioning aquatic ecosystems has been challenging, as the social acceptance of hydropower often becomes framed as a conflict between hydropower and migratory fish. Future research would do well to ask, what aspects of the water governance regime

are open to change and what remain unchallenged? To enable pathways for socio-ecological transformations of aquatic ecosystems further scientific scrutiny must be focused on river restoration, recreational uses of aquatic environments and the flexible energy function of hydropower in energy transition in the context of global change require.

This article has wider implications for understanding sustainability trade-offs and environmental conflicts related to hydropower. In the global context, the relevance of hydropower for electricity systems as a source of flexible energy is increasing as climate policies drive the transition to a carbon-neutral society and industry representatives use the climate crisis to reframe and protect their economic interests (e.g. Zarfl *et al*. 2015; Abazaj *et al*. 2016). Furthermore, the river regulation needed to give impoundment facilities the flexibility required of hydropower causes changes in water levels which may be a potential source of conflict between riparian residents and hydropower operators. Similarly, sustainable hydropower of the future in Finland is mostly framed as flexible and large-scale, based on existing or decreased rather than increased capacity. The significance of large-scale power plants in the national grid might be enough to justify negative ecological impacts, whereas locally viable compensation measures with tangible benefits should be pursued to reinstate ecological flows instead of sustaining small-scale hydropower plants.

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