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Role of Dams and Reservoirs in a Successful Energy Transition

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Role of Dams and Reservoirs in a Successful Energy Transition – Boes, Droz & Leroy (Eds)

From energy producer to water manager: A research-industry collaboration

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ABSTRACT: The hydropower industry is expected to play a central role in the double field of energy transition and water security, in a context of climate change, increasing pressure on water resources and geopolitical tensions. The role of alpine hydropower infrastructure in the deployment of a multifunctional water management policy needs to be considered. A research project involving Alpiq and the University of Lausanne is developing this reflection, by clarifying the origin of the concept of multiple use of water and hydraulic infrastructure, the perceptions of multifunctionality by the various water and energy stakeholders, and the issues of governance of resources "water" and "hydraulic infrastructures", particularly in view of the dam relicensing. The work in progress demonstrates the common interest of this collaboration, which is fruitful for both science and industry.

RÉSUMÉ: L'industrie hydroélectrique est amenée à jouer un rôle central dans le double domaine de la transition énergétique et de la sécurité hydrique, dans un contexte de changement climatique, d'augmentation des pressions sur la ressource en eau et de tensions géopolitiques. Des réflexions doivent être menées sur le rôle des infrastructures hydroélectriques alpines dans le développement d'une politique de gestion multifonctionnelle de l'eau. Un projet de recherche associant Alpiq et l'Université de Lausanne développe cette réflexion, en précisant l'origine du concept de multiusage de l'eau et des infrastructures hydrauliques, les perceptions de la multifonctionnalité par les différents acteurs de l'eau et de l'énergie, et les enjeux de gouvernance des ressources « eau » et « infrastructures hydrauliques », notamment dans la perspective des retours de concessions. Les travaux en cours démontrent l'intérêt commun de cette collaboration, fructueuse autant pour la science que pour l'industrie.

1 INTRODUCTION

In the current context of strong pressure on water resources, linked to climate change, the energy transition and various political crises, the concept of "multiple use of water infrastructure" is put forward by various user sectors to deal with an increasingly complex distribution of the resource (Kellner and Brunner, 2021). For hydropower producers, this issue is becoming increasingly urgent and is being addressed at various levels. In order to better define the contours and challenges of this new paradigm and to develop proposals for future responses, Alpiq and the University of Lausanne (UNIL) have joined forces to conduct a research project on the multifunctionality of hydropower infrastructures in the Swiss Alps.

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1.1 *Origin, actors and purpose of the project*

The first discussions between UNIL, more specifically its Interdisciplinary Centre for Mountain Research (CIRM), and Alpiq began in 2019. The aim was to define the contours of joint research and to identify the motivations and contributions of each party. In 2020, UNIL launched a call for applications for a post-doctoral work focusing on the origin of the concept of multipurpose use of alpine hydropower reservoirs in Switzerland, its actors and the past, present and future evolution of this new management model for hydraulic infrastructure. Alpiq wished to extend the research on a more institutional axis and to question the governance of the resource. In this context, Alpiq has been financing a doctoral thesis since October 2021 on the analysis of the governance of the multifunctionality of dams and its perspectives. These two lines of research are being carried out jointly in three research centres of Lausanne University – the CIRM, the Swiss Graduate School of Public Administration (IDHEAP) and the Institute of Geography and Sustainability (IGD) – and will continue until autumn 2025.

The subject of the research was discussed at length: was it a question of questioning multifunctionality solely (or primarily) from the point of view of the water resource, as the main issue of rivalry of uses and regulation, or was it a question of adopting a more holistic and integrative approach that also considered the infrastructural resources constituted by the hydropower schemes? From an integrated management perspective, it quickly became clear to us that hydroelectricity should be considered as a *system* of resources that is indissociably composed of water and infrastructure. Such an approach has the advantage of making it possible to study not only the regulation regimes of each of the two resources, but also, and above all, to study their interdependence at the functional scale of the hydropower basin, i.e the use basin (Calianno et al., 2018) delineated by the hydraulic infrastructure. The postulate on which our research is based is therefore that the understanding of the management stakes of the multifunctionality of hydropower installations requires a combined analysis of the regulations – public law (public policies) as well as private law (concessions and other property rights) – concerning the two resources (water and infrastructure), in order to evaluate in particular the level of coherence between the various regulations.

2 CONTEXT

2.1 *Collaboration and motivations of each party*

2.1.1 *Motivation of the industrial partner*

In the context of current energy, political and climate crises and the renewal of hydropower concessions, the multiple use of water, and consequently the multifunctionality of hydropower dams, is a theme that an energy producer must integrate into business considerations. In the near future, Alpiq will probably no longer be a producer of hydroelectric energy alone, but will also be a water resource manager offering various services and products. This paradigm shift implies changes in terms of management and corporate philosophy; Alpiq needs to adapt its core business to the new direction of the hydropower market, in particular if multifunctionality is developing.

Collaboration with research allows developing a cross-disciplinary approach in which Alpiq can demonstrate its skills as a manager and not just as an electricity producer. This strategy will be necessary in discussions with the various stakeholders on hydropower relicensing. The integration of Alpiq, an industrial player, in this research project allows it to be part of a global societal project and to profile itself as a sustainable manager of water resources. Thanks to its expertise, Alpiq can provide its engineering point of view on its ability to manage large catchment areas and structures, and on the implementation of potential future developments, and also make available historical and current operating data to researchers.

2.1.2 *Motivation for the research*

During the period 2016-2021, UNIL Rectorate has placed the development of inter- and transdisciplinary research as one of its priorities. As mountain themes are very present within UNIL, the Interdisciplinary Centre for Mountain Research (CIRM) was created in this

context in autumn 2018. From the beginning, it has been placed in a resolutely transdisciplinary perspective (Reynard et al., 2020), with the objective of co-developing joint research with territorial actors. Collaborations have thus emerged, notably with local museums, regional nature parks, and associations active in the Valais and Vaud Alps, which have been defined as privileged territories for the development of CIRM research. The joint reflection undertaken with Alpiq is part of this dynamic.

For the UNIL research team, collaboration with an industrial player has several advantages. Firstly, it allows the conceptual models to be confronted to the concrete expectations of stakeholders. Secondly, the collaboration between research and industry augurs a potential application of the recommendations resulting from the research; such collaborations are rare in the field of human and social sciences. Finally, this research project is in line with CIRM's commitment to develop transformative research, with the aim to transform Alpine territories towards greater sustainability.

2.2 *Two lines of research*

The first axis (Figure 1) is a socio-historical research. The objective is to find out when and how the term multifunctionality appeared in the scientific literature, in strategic documents on water and energy management, and in the public debate in Switzerland (task 1a), and how it is perceived and understood by water and energy stakeholders, both at the national and cantonal levels (1b) and at the level of the hydropower schemes themselves (1c).

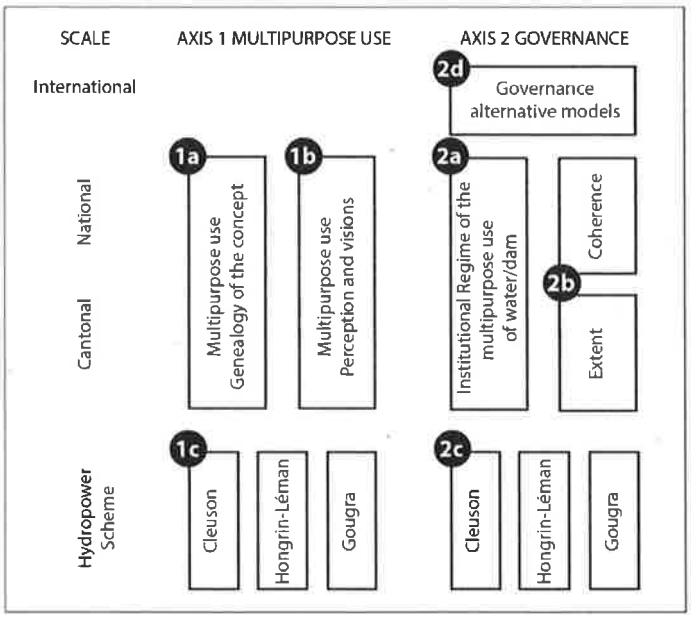

Figure 1. Research organisation.

The second axis focuses on the institutional side and the regulation of the various uses using the institutional resource regimes (IRR) analytical framework (task 2a). The aim is to describe the extent of regulated uses and the coherence of the governance of multifunctionality (2b). The problem is first addressed at the national and cantonal levels, before being studied in three case studies at the scale of specific schemes (2c). The second part of the project focuses on the study of institutional solutions developed abroad (2d) with the aim of establishing new governance scenarios that could be transposed to Switzerland.

3 METHODOLOGY

3.1 *Analysis of the multifunctionality of hydropower dams*

The first part of the work (Task 1a) focuses on the emergence of the concept of multifunctionality – of water and hydropower infrastructure – in Switzerland (Flaminio and Reynard, 2022, 2023). We studied the definitions associated with this concept, their evolution over time and the visions associated with them at the national and cantonal levels, using the example of the canton of Valais, the largest hydroelectric producer in Switzerland. The work is based on a corpus of documents (reports from various federal and cantonal offices, government messages and parliamentary interventions, scientific reports, etc.) as well as on 22 semi-structured interviews with various water and energy stakeholders in Switzerland and in Valais (politicians, members of the administration, scientists, representatives of professional or environmental associations).

In a second step (1b), we studied the documentary corpus and the interview transcripts from the perspective of the perception of the concept by the different groups of stakeholders. This allowed us to identify groups of representations that we aggregated around three main visions of the multifunctionality of water and alpine dams.

As multifunctionality is primarily seen as a possible adaptation to climate change at regional and local levels, case studies of existing schemes should investigate how multifunctionality is considered by water and energy stakeholders at local and regional levels (1c). For obvious reasons of ease of access to data, three case studies of Alpiq schemes were selected. Size, geographical and topographical location, mode of operation and multifunctional character were the main characteristics used to select the case studies. In Valais, the Cleuson dam in the Printse valley and the Gougra dam in the Anniviers and Turtmann valleys were selected. The Hongrin dam in the canton of Vaud completes the sample. These three schemes are very different both geographically and administratively and thus allow the broadest possible view of the existing or potential multifunctionality of dams.

For each case, after defining the perimeter of the study, which depends as much on the hydrological components (watershed) as on the infrastructures (basin of uses), we mobilise a corpus of documents (concessions and other administrative documents, scientific studies, study reports relating to projects, local press) and interviews with stakeholders concerned by the use of water and the infrastructure (15-20 interviews per case). The objective is to obtain an inventory and characterisation of the various uses, their temporal evolution, a quantification of water withdrawals and an analysis of rivalries and complementarity between uses. In the continuation of the study at national and cantonal level (Flaminio and Reynard, 2022), we also seek to establish what visions the actors involved in specific schemes have of water and aquatic environments, of hydropower and of multifunctionality.

3.2 *Analysis of the governance of the multifunctionality of hydropower dams*

The analysis of governance is carried out using the theoretical framework of institutional resource regimes (IRR) (e.g. Knoepfel et al., 2007; Varone et al., 2008; Gerber et al., 2009). The aim of this approach is to study the links between the multifunctionality of the uses of a resource, the institutional rules regulating and arbitrating these uses, the configuration of the actors concerned by the uses and regulations and, finally, the effects on the sustainability of resource management. It has already been used on numerous occasions to analyse the regulatory regimes of water resources (e.g. Varone et al., 2002) as well as those of various infrastructure resources (e.g. Nahrath et al., 2011).

More concretely, by combining a public policy analysis approach (Knoepfel et al., 2010) and an approach based on the institutional economics of resources (Ostrom, 1990), the framework for analysing IRR makes it possible (Knoepfel et al. 2007) to: (i) identify all the uses (goods and services) that are made of a given resource and to identify any phenomena of rivalry and scarcity resulting from this multifunctionality; (ii) systematically and exhaustively describe all the rules – both public law (public policies) and

private law (Civil Code, Code of Obligations, etc., defining property rights, in particular concessions) – that make up the IRR; rules that regulate the allocation of use rights over the various goods and services; (iii) to characterise the IRR using two dimensions: its extent – understood as the number of goods and services regulated by the regime – and its coherence – understood as the level of coherence or incoherence, both between different public policies (e.g. energy (hydropower), environment, tourism, flood control, agriculture (irrigation), etc.), and between public policies and property rights (e.g. incoherence between the turbining rights conferred by concessions and the obligation to guarantee minimum flows imposed by water protection policy).

The study of the institutional regime of the multifunctionality of water and dams (Task 2a; Savoy et al., 2023) first required the elaboration of a list of all the uses that could theoretically be made of alpine hydroelectric schemes in Switzerland, classified into 9 main categories and 41 specific uses, as well as a definition of the resources "water" and "hydropower infrastructure" and their uses. Tables of the current uses of these two resources and of the negative externalities of hydraulic infrastructures were thus established. Four groups of rivalries between uses were established: rivalries over the allocation of water in the reservoir, rivalries over the use of the power schemes, rivalries over the use of the reservoir itself and finally, rivalries over the use of the infrastructures.

The analysis of the institutional regime of hydropower activity is based on legal texts (Constitution, laws and ordinances or decrees, Civil Code, Code of Obligations) and political texts (e.g. messages from the Federal Council or cantonal State Councils), both at national and cantonal level (Valais and Vaud). The characterisation of the regime is organised around seven major groups of uses defined according to their relevance in the governance of the multifunctionality of alpine dams and according to the institutional density, i.e. the "volume" of legislative texts concerning them. These uses are: hydropower production, ecosystems and landscape, flood management, agriculture and irrigation, drinking water supply, artificial snowmaking, other uses. For each use group, the history of regulation, the triangle of actors (Knoepfel et al., 2006) and the constituent elements of the political-administrative programme are analysed. For each group of uses, the formal property rights, the disposal rights and the use rights, as defined in particular in concessions and other private law documents, are then identified.

On this basis, we carry out a study of the extent and coherence of the regime (task 2b). For the extent, we establish how intensively the uses are regulated and we also identify which uses are not or only weakly regulated.

The same approach is then applied at the scheme level (Task 2c). The selected schemes are the same as for Task 1c. In contrast to the analysis at national and cantonal level, which is based primarily on a corpus of legislative, legal and political texts, the study at the scheme level also uses semi-structured interviews with actors managing and using the infrastructures. The aim is to define the contours of the local regulation arrangement (LRA; Schweizer, 2015; Viallon et al., 2019) and in particular to identify the mechanisms governing the multifunctional use of the resource and infrastructure that escape or complement the legal regulation by the national and cantonal regulation regime, and are subject to more or less formalised local arrangements (conventions, customary rules, informal oral agreements, etc.)

Finally, the aim is to identify and study, on the basis of scientific literature and possibly *in situ* case studies, forms of regulation of multifunctionality developed in other countries (task 2d). These cases will make it possible to reflect on alternative forms of regulation of multifunctionality that could be mobilised in Switzerland when relicensing power schemes.

4 FIRST RESULTS

4.1 *Genealogy and perception of the concept of multifunctionality of water and infrastructure*

The results of tasks 1a and 1b of the project (Flaminio and Reynard, 2022, 2023) show that the notion of multifunctionality of water and dams is still unclear for many actors. Nevertheless, it is beginning to stabilise. Its emergence in the literature on water and energy in

Switzerland is quite recent. The multifunctionality of dams was first mentioned in federal reports on climate change, and in scientific studies on the adaptation of the hydropower sector to climate change in the early 2010s. From the mid-2010s onwards, various documents give it more prominence. Since 2018, the concept of multifunctionality of water and dams has developed both in scientific publications and in reports from various federal and cantonal administrations. Overall, multifunctionality is discussed in connection with the debate on adaptation to climate change and could concern both existing infrastructure – which is the reason why, according to the sources consulted and the testimonies collected, it should be discussed before the relicensing of power schemes – and the construction of new infrastructures or the modification of existing ones.

The analysis of the interviews reveals three main visions of multifunctionality (Flaminio and Reynard, 2022, 2023): (i) the first is defined as a vision supporting the hydroelectric sector under pressure from environmental requirements, and considers it unnecessary and costly to implement; (ii) the second vision considers multifunctionality beneficial and interesting, particularly suitable as an instrument for adapting to climate change and decreasing water resources; (iii) the third vision, carried by actors particularly sensitive to the impacts of hydropower production on the environment, considers the notion of multiple use of water as purely rhetorical, with the objective to rehabilitating the image of hydropower, and not allowing for a paradigm shift towards more sustainable water management.

4.2 *First lessons from the Cleuson case*

The Cleuson dam is located in the Printse watershed, in the commune of Nendaz, on the left bank of the Rhone River. It was commissioned progressively from 1948 and has a capacity of 20 million m^3. It is part of the Grande-Dixence hydropower complex. The water is not turbined directly, but pumped to the Grande-Dixence reservoir before being turbined in one of the Cleuson-Dixence power stations.

The first results of the analysis of uses and stakeholders (Flaminio, 2023) allow us to consider water as a multifunctional resource in this valley. Indeed, it is used and valued by many sectors of use. Various uses are present around the infrastructure and some even precede the construction of the dam, such as irrigation, practised since the Middle Ages thanks to a network of ten *bisses* (traditional irrigation channels) which divert the Printse waters, or fishing. Other uses have been added over time following the emergence of new needs, such as the production of drinking water, from the end of the 1960s, and artificial snowmaking, from the beginning of the 1990s. On the other hand, some uses have disappeared, such as the use of hydraulic power to drive mills and other hydraulic devices in the middle Printse valley (Beuson), which were replaced by electrical power following the construction of the Cleuson scheme (Reynard, 2000). The Cleuson reservoir also plays a role in flood hazard prevention by being integrated into the Minerve scheme (García Hernández et al., 2010), following an agreement signed in 2008 between the hydropower operator and the Canton of Valais. The water stored in the Cleuson reservoir is also used as a reserve in case of fire, via withdrawals from the drinking water network. The Cleuson lake also contributes to the valley's tourist image and thus has a certain tourist value, essentially during the summer period. Lastly, the withdrawals have a certain impact on the flows and aquatic environments.

Although the reservoir has multiple uses, it should be noted that uses other than hydropower production remain limited from a quantitative point of view, representing less than 5% of the volumes stored in the Cleuson reservoir. Hydroelectric use thus represents around 23.7 million m^3, withdrawals for irrigation are only made in dry years and reach a maximum of 750,000 m^3 (in 2022), while withdrawals for the production of drinking water and artificial snow are of the order of 90,000 and 130,000 m^3 respectively. This means that approximately 1 million m^3 per year (maximum) can be withdrawn from the Cleuson reservoir, i.e. 4.2% of the stored volume.

Today, this gives rise to fairly strong complementarity dynamics and little competition as regards the uses linked to the exploitation of water. On the other hand, there is a certain competition between the exploitation uses (withdrawals) and the protection of the resource.

During the interviews conducted with the various stakeholders in the region, the issue of climate change and the related challenges was raised. The majority of those interviewed are aware of the need in the more or less near future to better anticipate shortages and to implement integrated management of the resource, but for the time being, the sharing between the different uses is not anticipated, as water is still not under much pressure in this region.

5 CONCLUSION - STRENGTHS OF A RESEARCH/INDUSTRIAL PARTNERSHIP

Today, Switzerland is at the interface of two issues with different dynamics that need to be considered together: (i) the energy strategy which, in the dynamics of decarbonation of the economy and society, the gradual abandonment of nuclear production and the reduction of energy dependence on foreign countries, intends to reinforce the production of indigenous renewable energy, within which hydropower energy plays a central role; (ii) the water management strategy, which requires a paradigm shift towards greater integration, driven by climate and hydrological changes, of which the last twenty years have shown that Switzerland is not immune to extreme events and shortages, despite its relative water wealth. For this reason, the Federal Council (2022) has pointed out the need to strengthen water security. In this context, the implementation of integrated water management includes the use of the large alpine hydropower reservoirs as storage infrastructures to adjust water supply to demand. It also requires the development of shared water governance mechanisms, which are still underdeveloped at the moment.

The objectives of these two public policies – electricity supply and water supply – seem *a priori* to be competing, but hydropower producers could play a central role in this double transition because of their position at the interface between the two policies, because of the importance and geographical spread of the infrastructures and because of their expertise in hydraulic matters based on a century and a half of practice in the field. As for research, particularly in the human and social sciences, it provides the theoretical and methodological basis necessary to carry out a good diagnosis of the existing situation and to provide a solid foundation for relevant reflection on future scenarios. The importance given to the analysis of the perceptions of the issues by the stakeholders and the governance mechanisms at stake should thus make it possible to better understand tensions that could transform in conflicts when the concrete projects are implemented (Utz et al., 2017).

Through this research project, Alpiq and UNIL are seeking to link the fields of energy and water management, to go beyond existing operating models and develop broader socio-political models that cross these two fields. The industrial partner is often a driving force and proactive in these reflections on paradigm changes. In association with science, the industry can reflect on the possible transformations in water supply, both technical and in relation to hydrological evolution, uses and rivalries, etc. In parallel, they can carry out reflections on innovative modes of governance and comparative prospection work. Subsequently, the industrial partner hopes to be able to propose concrete solutions for the governance of the resource to politicians.

REFERENCES

Calianno, M., Milano, M., Reynard, E. (2018). Monitoring water use regimes and density in a tourist mountain territory. *Water Resources Management, 32*, 2783–2799.

Conseil fédéral (2022). *Rapport de base sur la sécurité de l'approvisionnement en eau et sur la gestion de l'eau.* Rapport du Conseil fédéral en réponse au postulat 18.3610 Rieder du 15 juin 2018. Berne: Conseil fédéral.

Flaminio, S. (2023). *Analyse de la multifonctionnalité des aménagements hydroélectriques alpins: le cas de Cleuson (Valais).* Working paper n°2 du projet « Multifonctionnalité des infrastructures hydroélectriques alpines ». Lausanne: Université de Lausanne, 77 p.

Flaminio, S., Reynard, E. (2022). *Une généalogie de la multifonctionnalité des barrages-réservoirs en Suisse.* Working paper n°1 du projet « Multifonctionnalité des infrastructures hydroélectriques alpines ». Lausanne: Université de Lausanne, 30 p.

Flaminio, S., Reynard, E. (2023). Multipurpose use of hydropower reservoirs: Imaginaries of Swiss reservoirs in the context of climate change and dam relicensing. *Water Alternatives*, under review.
García Hernández, J., Horton, P., Tobin, C., Boillat, J.-L. (2009). MINERVE 2010: Prévision hydrométéorologique et gestion des crues sur le Rhône alpin. *Wasser Energie Luft*, *4*, 297–302.
Gerber, J.-D., Knoepfel, P., Nahrath, S., Varone F. (2009). Institutional Resource Regimes: Towards sustainability through the combination of property-rights theory and policy analysis. *Ecological Economics*, *68*(3), 798–809.
Kellner, E., Brunner, M. I. (2021). Reservoir governance in world's water towers needs to anticipate multi-purpose use. *Earth's Future, 9*, e2020EF001643.
Knoepfel, P., Larrue, C., Varone, F. (2006). *Analyse et pilotage des politiques publiques* (2nd ed.). Zürich: Verlag Rüegger.
Knoepfel, P., Nahrath, S., Varone, F. (2007). Institutional regimes for natural resources: An innovative theoretical framework for sustainability. In P. Knoepfel (Ed.), *Environmental Policy Analyses. Learning from the Past for the Future - 25 Years of Research* (pp. 455–506). Berlin: Springer.
Knoepfel, P., Nahrath, S., Savary, J., Varone, F. (2010). *Analyse des politiques suisses de l'environnement*. Zürich/Chur: Ruegger Verlag.
Nahrath, S., Pflieger, G., Varone, F. (2011). Institutional Network Regime: a new framework to better grasp the key role of infostructure. *Network Industries Quarterly*, *13*(1), 23–26.
Ostrom, E. (1990). *Governing the Commons. The evolution of institutions for collective action*. Cambridge: Cambridge University Press.
Reynard E. (2000). *Gestion patrimoniale et intégrée des ressources en eau dans les stations touristiques de montagne. Les cas de Crans-Montana-Aminona et Nendaz (Valais)*, Thèse de doctorat, Université de Lausanne, Lausanne: Institut de Géographie, Travaux et Recherches n° 17, 2 vol., 371 p.
Reynard, E., Otero, I., Clivaz, M. (2020). The Interdisciplinary Centre for Mountain Research (CIRM): Fostering transdisciplinarity for transformation research in mountains. *Mountain Research and Development*, *40*(2), P1–P3.
Savoy, A., Nahrath, S., Reynard, E. (2023). *Analyse juridique du régime institutionnel de l'activité hydroélectrique*. Working paper n°3 du projet « Multifonctionnalité des infrastructures hydroélectriques alpines ». Lausanne: Université de Lausanne, in prep.
Schweizer, R. (2015). *Stratégies d'activation du droit dans les politiques environnementales. Cas autour des bisses valaisans*. Zürich: Rüegger Verlag.
Utz, S., Clivaz, M., Reynard, E. (2017). Processus participatifs et projets d'aménagement des cours d'eau. Analyse de l'implication des acteurs dans la planification du projet de 3ème correction du Rhône suisse entre 2000 et 2015. *Géocarrefour* [En ligne], http://geocarrefour.revues.org/10140
Varone, F., Reynard, E., Kissling-Näf, I., Mauch, C. (2002). Institutional Resources Regimes. The case of water in Switzerland. *Integrated Assessment. An International Journal*, *3*(1), 78–94.
Varone, F., Nahrath, S., Gerber, J.-D. (2008). Régimes institutionnels de ressources et théorie de la régulation. *Revue de la régulation, 2* [en ligne]. http://regulation.revues.org/
Viallon, F.-X., Schweizer, R., Varone, F. (2019). When the regime goes local: Local regulatory arrangements and land use sustainability. *Environmental Science & Policy*, 96, 77–84.