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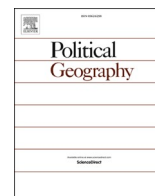
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Full Length Article

Towards hydrosocial autonomy within modernity. A long-term analysis (1850–1980) of socio-material fracturing of flood protection infrastructures in an Alpine valley

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ABSTRACT

This paper retraces the history of flood risk infrastructure projects (1850–1980) in the Grésivaudan Valley, located immediately upstream of Grenoble (France). It analyses the persistent gap between the modernist paradigm embedded in flood protection projects and the concrete hydraulic infrastructure built along the river and at confluences, questioning their unexpected effects. In this article, we demonstrate that in spite of their apparent fixity, flood protection infrastructures are constantly reshaped within hydrosocial territories. To support this argument, we analyse socio-material fracturing arising from the implementation of flood infrastructure projects. Four autonomisation processes that produce these socio-material fractures are studied: a) a competition between imaginaries at stake; b) a situation of legal pluralism denied by the State; c) an agency of sediments; and d) a conflict between the everyday practices of beneficiaries and planned practices. By reconstructing these processes, we open the black box of the hydrosocial construction and materialisation of hydraulic infrastructure, and contribute to the development of the concept of socio-material fractures.

1. Introduction

In the wake of the so-called “infrastructural turn” in social sciences (Dodson, 2017), a rich body of research developed exploring the links between infrastructure, spatialities, and territorialisation processes. Overcoming “the divide between material infrastructure on the one hand, and social superstructure on the other” (Latour, 2000, p. 51), this research examines infrastructure not only as physical objects composed of materials but also as politically charged entities (Akrich, 1992; Anand et al., 2018; Gurung, 2021; Obertreis et al., 2016; Winner, 1980). To analyse the specificities of water issues in relation to infrastructure, Boelens et al. (2016) propose the concept of a hydrosocial territory (HST for short in the text below) as “the contested imaginary and socio-environmental materialisation of a spatially bound multi-scalar network in which humans, water flows, ecological relations, hydraulic infrastructure, financial means, legal-administrative arrangements and cultural institutions and practices are interactively defined, aligned and mobilized through epistemological belief systems, political hierarchies

and naturalizing discourses” (Ibid: 2). A HST, as they explain, has functions, values, and meanings that are often contested but play a crucial role in shaping inclusion and exclusion processes, development, and the distribution of benefits and burdens that affect various groups of people in different ways. The concept has led to a better understanding of the impact of infrastructure development within territories, showing that major infrastructure projects often conflict or recurrently become disconnected from territory dynamics (Drapier et al., 2024).

Building on these emerging insights and to disentangle the agential role of infrastructure, Hommes et al. (2022: 2) conduct an extensive literature review in which they detail examples of how “social, political, environmental and material relations change as a result of infrastructure construction.” For them, “the built infrastructure is an ultimate attempt to fix an imaginary and create a corresponding hydrosocial territory and [associated] subjectivities” (Ibid: 5). They further describe this process as dynamic, always in the (re)making, resulting from and contributing to the infrastructures’ agential role. In this dynamic process between the human and nonhuman, the HST produces “Socio-Material Fractures”

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(SMFs for short in the text below) defined as the misfit between a flood protection project defined by State engineers and its materialisation in the HST (Ibid: 6). In their conclusion (Ibid: 7), the authors invite other scholars “to apply, test and further develop” the notions they propose in order to “scrutinize the complex role of infrastructure in the making and remaking of hydrosocial territories”.

This contribution responds to this invitation in the field of flood protection that remains under-exemplified compared to the fields of irrigation and drinking-water. We focus on flood protection infrastructure in an Alpine valley of the Isère River upstream of Grenoble, France, namely the Grésivaudan Valley. We discuss its interaction with the social superstructure from 1850 to 1980, during what we term the Modernist Era,¹ highlighting the dynamic nature of the HST through a detailed analysis of its history.

More specifically, this contribution brings particular attention to the nascent notion of SMFs. In our understanding, a SMF does not mean that an infrastructure project is unachieved, but rather that ‘oddities’ appear in a project implementation, in the fixing of a territorial imaginary (Ibid: 4). Components of the project become progressively autonomous through their continuous reshaping by unforeseen or evolving relational processes of the HST. These components take the form of objects or subjects that are individuated in a way that was not anticipated in the project definition.

The SMF analysis in this article brings a complementary view ‘from the inside’ to scholarship that focuses ‘from the outside’ on the political role of large centralised development programs related to flooding (Harris, 2012; Menga & Swyngedouw, 2018; Swyngedouw, 1999) and on the imaginaries of State engineers that we find in the work of Denis Coeur (2008) for the case of Grenoble. This SMF analysis also extends the analysis of the multiple territorial resistances (Brochet, 2017, p. 802) observed during the implementation of the flood protection projects that preceded the Modernist Era.

We conducted archival research, fieldwork, literature reviews, and primary and secondary data analysis. In our investigation, the key papers of Agard (1942) and unpublished technical reports like Oumin (1961), Decrop et al. (1997, p. 235), Belleudy (2007, p. 186) or EGIS (2011, p. 47) oriented us to appropriate archives. Over 100 archive documents stored at the Archives Départementales de l’Isère were reviewed, among which 37 are used in the paper (see Appendix A).

This paper is organised as follows. In the first section, we present a literature review to frame the notion of SMFs in infrastructure studies. In the second section, we describe the space and time limits of our study and depict the state of the HST at the beginning of the analysis period. In the third section, we analyse how conflicting imaginaries about the dike system led to preservation of river meanders. Section four demonstrates how community legal order influenced the legal framework fit with infrastructure elements. Section five illustrates how the sediments became an agentive force to transform infrastructure. Section six describes how everyday practices played a role in the materialisation of the hydraulic infrastructure, transforming the initial function of lateral channels.

¹ The modernist era can be seen as a period during which centralised planning knowledge and practices based on abstract, overarching and standardised approaches were favoured. Applied to flood protection, the aim of these approaches was to *fight against floods*, which were perceived as natural phenomena external to society, and which needed to be brought under human control. This era lasts until the environmental turn in flood risk management (Van Ruiten & Hartmann, 2016) of the late 20th Century, characterised by an effort to incorporate natural flood attenuation approaches of the river and its ecosystems, and a flood adaptation approach, based on the imaginary of *living with floods*.

2. From infrastructure dynamics to socio-material fractures – a literature review

Infrastructures are massive objects that often appear as a static materialisation of State power. Infrastructure takes years or even decades to develop and its life cycle can be several centuries (Appel et al., 2018), and can transform the landscape on a large scale. Adding the complexity of the institutional arrangements that support these infrastructures (Hommels, 2005), we understand why infrastructures “have long become symbols of stability and durability” (Obertreis et al., 2016, p. 172), and are endowed with a high degree of path dependence (Melosi, 2008). However, we can question the notion of these objects being static and not dynamic. Historians of technology were the first to account for the transformations of infrastructures. They favoured a linear and evolutionary approach to transitions, centred on technological innovation (Hughes, 1983, p. 473). Nevertheless, the development of infrastructural studies led to the emergence of a more political and social representation of infrastructure transformations (Akrich, 1992; Graham & Marvin, 2001; Winner, 1980).

Along those lines, political ecologists have developed a “political ecology of the State” (Tarr, 1984; Guy et al., 2001; Nüsser, 2003; Molle & al., 2009; Bénit-Gbaffou & Oldfield, 2011; Meehan, 2014; Rodina & Harris, 2016; Harris, 2017; Loftus, 2020). This scholarship has shown how large-scale hydraulic projects developed by the State align with a technocentric logic (Harris, 2012; Menga & Swyngedouw, 2018; Rusca et al., 2019; Swyngedouw, 1999) aimed at legitimising and consolidating State power (Crow-Miller et al., 2017; Perreault, 2005). In this framing, infrastructures are analysed as objects attempting to “fix” modern imaginaries of the State (Auvet, 2019, p. 603; Fry & Murphy, 2021; Hommes et al., 2022; Mills-Novoa et al., 2020; Raffestin & Butler, 2012; Ward & Zunz, 1997) or materialise political ideologies, like Keynesianism or neo-liberalism (Coutard & Rutherford, 2015; Graham & Marvin, 2001). In a similar vein, Scott (1998, p. 464) has studied the infrastructures of “high modernist regimes,” taking account of the central role played by the State in the development of major infrastructures, particularly water. Other authors have shown that powerful non-state actors, such as international investors and firms, support the State in this work (Bichsel, 2012; Tilt, 2016). Thus, the transformation of infrastructures is generally viewed by political ecologists as the result of State policies.

In response to these works representing infrastructures as integrated and functional overarching systems symbolising State power, anthropologists have highlighted that infrastructures often take the form of incomplete, unfinished and fragmented systems (Harvey, 2015, 2018). As such, infrastructures have been analysed as political promises, which are sometimes abandoned (Gupta, 2018), “reflecting the desires, hopes, and aspirations of a society, or of its leaders” (Appel et al., 2018, p. 19). The transformation of infrastructures is not seen as linear, but rather as a contingent and contested dynamic, strongly linked to the context of action (Baker, 2020; Bruun Jensen & Morita, 2017; Furlong, 2011). Infrastructure therefore appears as a “fundamentally relational concept” (Leigh & Ruhleder, 1995), as “sites of conceptual trouble that refuse the easy separation of the human and the material” (Appel et al., 2018, p. 27), “like cauldrons in which multiple forms of materials intermingle” (Bruun, 2015 : 20). This may explain why many infrastructures—developed by nation-states to show that the State is advanced and modern—sometimes remain incomplete, in a state of “in-between-ness,” between the hope of progress associated with the construction of the infrastructure and the suspension of this hope afterwards (Gupta, 2018).

As a result, infrastructural change most often takes the form of socio-technical tinkering (Kemerink-Seyoum, 2019). Infrastructure “deviates from formal or public plans, technical designs and normative laws” and materialisation “is a never-complete process” (Ibid: 4). This research, rooted in Science & Technology Studies, explores issues such as, the social construction of infrastructure (Hughes, 1989; Pinch, 2010);

infrastructure as relational entities (Bowker et al., 1995; Leigh Star, 1999); as materials with agentive capacities (Bennett, 2010; Strang, 2016; Anderson & Wylie, 2009); or as “ontological experiences” (Bruun Jensen & Morita, 2017). Infrastructures are thus perceived like open and evolving systems that are constantly reconfigured and transformed (Coutard, 1999; Geels & Kemp, 2007).

Hydrosocial theory integrated these different insights, and took into account the dual dimension of stability and dynamism in infrastructure. In their literature review on infrastructure and HST, Hommes et al. (2022: 7) remind us the core opposition between “the grounded and bounded characteristics of territories and fixity of infrastructure” and “the fluidity and dynamic nature of water, society and socioterritorial relations.” On the one hand, the State, as a powerful actor, tries to fix materially and permanently the infrastructure, and in doing so, to define new homogeneous and productive subjects in the HST. On the other hand, “configurations triggered by infrastructure rarely materialise as planned.” To explain this well-known gap between the infrastructure project and its materialisation, Hommes and colleagues propose the notion of SMFs as “social and natural alterations to the utopian plans,” which makes the infrastructure “underperform” (Ibid: 6). Explanations of this phenomenon pertain to the unpredictability of the HST in terms of “a) nature (floods and droughts, soil erosion and sedimentation, etc.), b) infrastructure and its intrinsic properties in use (wear and tear), and c) the social system that controls, manages and uses the infrastructure and related water flows” (Ibid: 6). As such, SMFs become an inherent part of infrastructure projects, but remain open for study. This paper contributes to this effort, examining the appearance of four SMFs triggered by conflicts of imaginaries, norms, materials and practices. These four infrastructure ‘oddities’ that we interpret as SMFs include the resistance of meanders against the straightening of a river, the survival of community legal order over State law, the peril of water control caused by ignoring sediment flow, and the autonomisation of ‘Swiss Army knife’ channels.

3. The Grésivaudan Valley - A long history of flooding and the birth of the modern project of the state engineer Cunit

“Grenoble and its countryside are like the high sea” (Blanc La Goutte, 1733, re-edited in 2002: 109).

This line from the poet Blanc La Goutte perfectly illustrates the flood² that the City of Grenoble experienced on the 14th and 15th of September 1733. Despite being an inland city far from the ocean, the turbulent flood waters probably gave the actual feeling of a city surrounded by the sea.

The City of Grenoble is located in a Y-shape glacier valley at the confluence of two main rivers driven by three mountain massifs with altitudes above 2000 m. The Isère River (5720 km² of upstream basin from Grenoble) naturally meanders (slopes of ca. 0.5/1000) from the northeast through the flat Grésivaudan Valley. The Drac River (3550 km² of upstream basin) is a more energetic, braided river (slopes of 1/1000) that comes from the south and joins the Isère near the historic city centre. The Isère leaves Grenoble toward the northeast toward the Rhône Valley with a braided bed morphology. Along their courses, the two rivers receive many torrential tributaries sourced from the surrounding mountain massifs (basin surfaces of 10-1000 km²) (Creutin & Sanseverino-Godfrin, 2018). We limit our analysis to the east branch of the Isère River upstream of Grenoble, the Grésivaudan Valley (see Fig. 1), where there are no less than 20 significant torrents that join the river in 30 km, i.e., almost one confluence per kilometre. The two levels of confluences (i.e., the Isère and Drac Rivers and the Isère River and its torrents) contribute to the region’s geophysical instability. Historically, sediments brought by Drac River floods regularly blocked the Isère’s

flow, aggravating floods in the city. The cones of sediment accumulated at the slope breaks of torrents made the confluence areas highly unstable, with the torrent streambeds changing after each flood (Dumas & Favillier, 2017). Despite their instability, confluence areas attracted and conditioned human activity. For example, the City of Grenoble was situated upstream of the confluence with the Drac at the only place where bridges could resist (Blanchard, 1910). At the same time, villages in the valley were systematically installed next to the sediment cones to take advantage of water power, construction material and access to altitude (Dubus & Fourneau, 1968). Due to these complex socio-material relations, confluences are privileged places of resistance to hydraulic infrastructure projects.

From the 13th to the 18th centuries, the flood risk that shaped the trajectory of the Grenoble Valley also spurred a long-lasting conflict between the City of Grenoble and, broadly speaking, the riparian owners³ of the Isère and Drac Rivers (Renou et al., 2020). The spirit of the local imaginary of riparian owners in the HST was, until then, of *living with floods*. Whereas, infrastructure projects pushed regulations, norms, and materials more toward a spirit of *fighting against floods*.

Between 1829 and 1853, the Sardinian administration of the County of Savoy designed and completed a straight and continuous embankment of the Isère River on its territory upstream of the Grésivaudan Valley. A series of 8 ravaging floods and 6 total crop losses in ten years (1837-8-9, 1840-3-4-5-6 after Agard, 1942) followed the Sardinian embankment initiative. The straightening of the river course and the massive narrowing of its bed (one-twentieth) in Savoy dramatically increased the river’s velocity and sediment transport capacity at the outlet of its embankment system in the Combe de Savoie. These floods ended the valley’s agricultural prosperity (Agard, 1942). As a result, in 1846, the local representative of the French State in Grenoble, the Prefect Pellenc, created a “Consultative Commission” in charge of i) a diagnosis, ii) the selection of the best measures of protection, and iii) the appropriate regulatory scheme for their implementation.

This Commission took into consideration previous engineers’ reports, the General Council and the Grenoble District Council deliberations, and petitions from several landowners. The Commission Report of 1847 (Appendix A - n°2) clearly distinguishes the upper and lower parts of the valley. The Upper Grésivaudan (from Chapareillan to Lancy - ca. 28 km) was considered better resistant to flooding than the Lower Grésivaudan (from Lancy to Grenoble - ca. 12 km). In the Lower Valley, the diagnosis of the Commission pointed to major problems. Firstly, the river meanders 24 km over a linear distance of 12 km of valley. Secondly, there is a constant variation in the width of the channel, from 80 to 200 m. Finally, sharp bends at certain angles bring the current across the valley several times, and, sometimes, the current is oriented toward the upper-valley.

Against the “two agents of destruction of the dikes,” referring to overflows and infiltrations (Agard, 1942, p. 737), the Consultative Commission defended a two-level system of protection. At the river level, the idea was to straighten the Isère River course with a uniform and well-maintained embankment (scales of typically 100 km and over). The explained advantage of linear channelisation to shorten the river course was that it would be more economical and better absorb the upstream flow. The major technical difficulty with the embankment was to deal with the multiple confluences of torrential tributaries in the flat and wet lateral plain. To solve the problem, the Commission defined an artificial confluence level, i.e., a network of open lateral channels draining minor torrents that took the local name of “chantournes” and a strategy of

² 5.57m over the low-water level in the urban section of the river (Pilot de Thorey, 1860, p. 131).

³ We use the term “riparian owner” to refer to the landowners with water-courses who have an obligation under French law to maintain the stream banks on their property. Until the 20th century this responsibility often took the form of maintaining flood protection dykes. In Grenoble, as we shall see later, it wasn’t until the 1930s and the creation of the ADIDR that this obligation to maintain dikes was transferred to a public body.

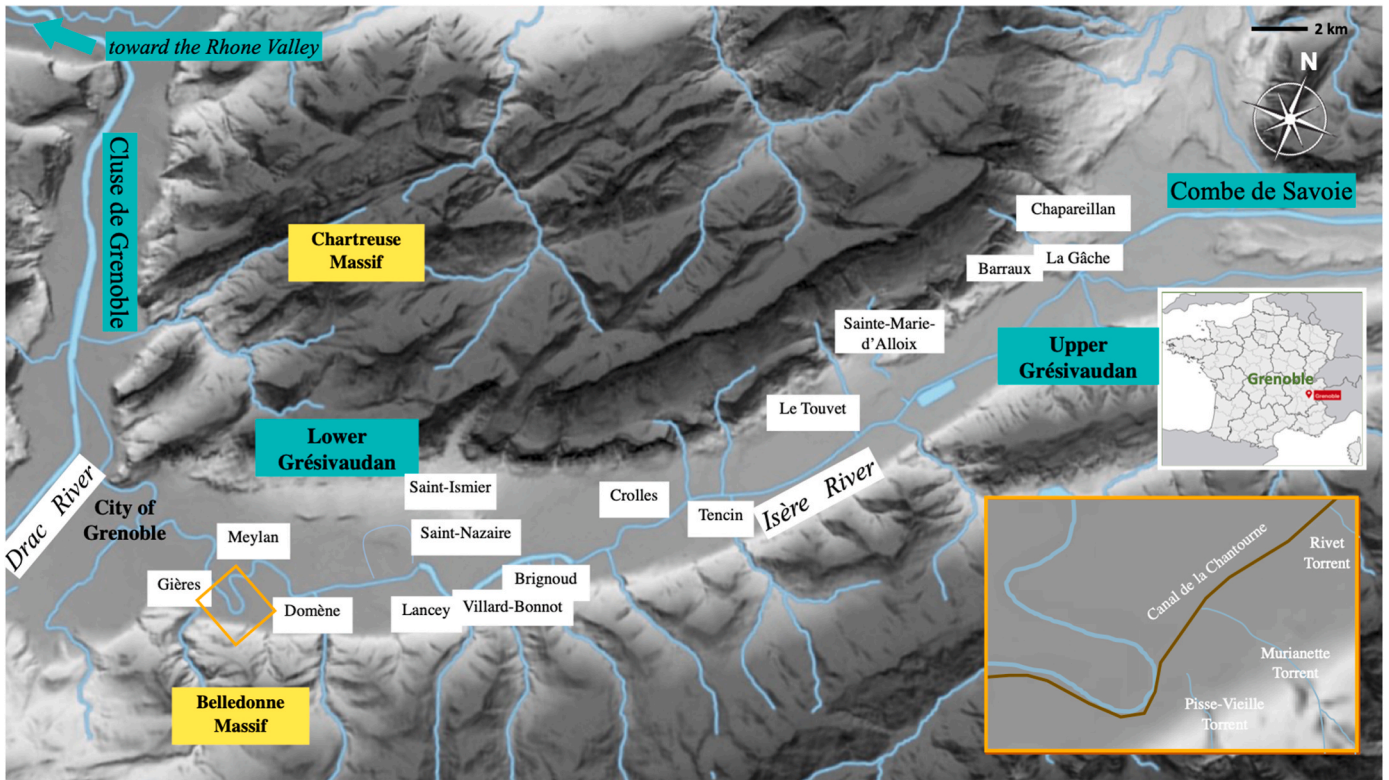


Fig. 1. The Grésivaudan Valley as a study area - Located in the south-east of France (upper inserted map), the Grésivaudan Valley is crossed by the Isère River flowing from the Combe de Savoie to the Cluse de Grenoble before reaching the Rhône Valley some 100 km downstream. The hydrographic network (light blue lines) shows many torrents draining high mountain ranges (yellow background lettering) and reaching flat valleys at populated confluences (white background lettering for the names of municipalities). The valley is divided in cultural regions (light blue background lettering). The bottom inserted map zooms in on an example of lateral infrastructure, chantourne, between Gières and Domène (orange rectangle on the main map). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
 Source: construction of the authors, 2023

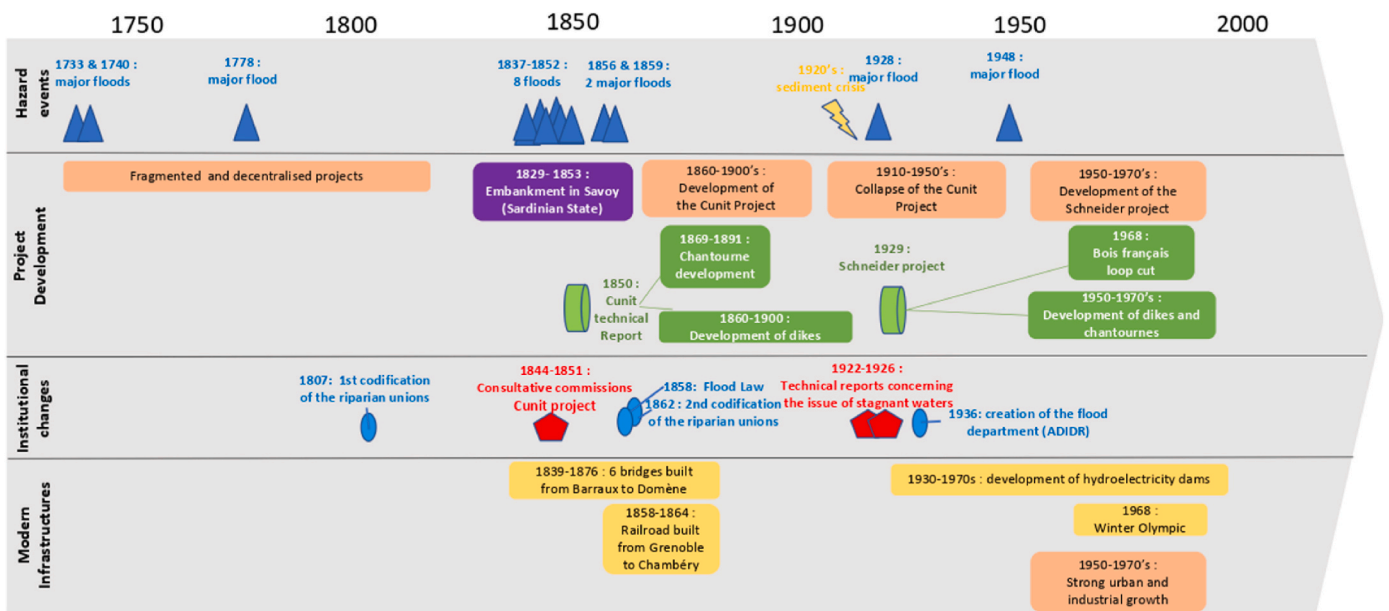


Fig. 2. Timeline from a pre-Modern to a Modern Era in water infrastructure projects in the Grésivaudan Valley (18th century - 20th century)
Legend: The graph represent the chronology of the flooding events (blue triangle) and the sediment crisis (yellow flash). The engineer projects (green cylinder) and their periods of implementation (green rectangle), the flood laws and regulations (blue ellipses) as well as administrative regulations (red hexagons) are represented below to mark the main infrastructure development steps. The last line represents the parallel development of other key infrastructure (yellow rectangles). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
 Source: construction of the authors, 2024

direct connection of the major torrents (see Fig. 3).

"[Chantournes], having a section capable of the volume furnished by the wells, filtrations, and small tributaries of the hillsides, will collect all the waters to bring them back to the river as low as the topography of the locality would permit. The extension of the canals is intended to restrict the number of mouths through which the backwash of the strong waters will expose the adjacent lands ... It will probably be necessary to divide the valley into sections of 6, 8, 10 km The strong streams, whose alluvial fans are not an obstacle, will continue to pour directly into the river, leaving by tunnels a free passage for the flow of the channels." (description of the lateral channel project by the Grenoble District Council developed in Section 6).

Our study period starts with the publication in August 1850 of the technical report of the State Engineer Cunit (Appendix A-n°6), who was the local State representative in the Consultative Commission launched by the Prefect Pellenc four years prior (see Fig. 2). Cunit's project is the first attempt in Grenoble to propose a complete utopian scheme to deal with the hierarchy of river and torrent confluences.

4. A first socio-material fracturing: contested modern imaginary about agricultural prosperity in a safe and salubrious valley (1850–1920s)

The project of the State Engineer Cunit opened what we call the Modern Era (1850–1980) and the imaginaries that followed suit, characterised by centralising management, controlling the river, and *fighting against floods*.

4.1. Content of the Cunit project

The Cunit project was, in priority, i) to straighten the river and drain the lateral plain between Domène and Grenoble, ii) to extend the same works in a second slice upstream between Barraux and Domène and iii) to create and operate a single public institution responsible for the realisation of the whole system with an ambitious timeline of two years (Appendix A – n°2). The project took little account of the pre-existing socio-material situation. Along a typically modernist paradigm, its authors believed in the virtue of simplification and clarification made possible by modern science. The project assumes more or less explicitly that a) H₂O water (Linton, 2010, p. 333) is de-embedded from its natural and social relations; b) hydraulic straightening of the riverbed is key to water evacuation; c) modern law is able to institute the management of water problems at the scientific scale of watersheds rather than the inhabiting community; and d) a scientific organization of work may control rational practices along the infrastructure.

The project, funded by State subvention and loans, was justified by several perspective benefits to the French nation. Firstly, to improve urban development and flood safety in the Grenoble city centre, with its inhabitants and the troops in charge of the defence of the place as a national gate (Grandvoinet, 2011). Secondly, to develop capitalist agriculture, servicing France in one of the most fertile valleys in the country (Veyret-Verner, 1937). Thirdly, to make river navigation easier with solid and well-established towpaths over the dikes, allowing the exportation of agricultural products, wood and minerals (Agard, 1942). Fourthly, to reduce water-related diseases by reducing stagnant waters (Sérandour et al., 2007). Finally, de facto, the project freed up land to develop new economic activities by straightening the riverbed and reducing its spatial footprint. Other Modern development projects were intertwined with that of Engineer Cunit. For example, the construction of six bridges along the valley from Barraux to Domène from 1839 to 1876 (Agard, 1942), as well as the creation of the railroad from Grenoble to Chambéry between 1858 and 1864 that triggered a debate about its role as a flood protection dike (Appendix A n°21; Giraud, 1861, p. 71).

4.2. Conflicting imaginaries about the Cunit project

After the work of the first Consultative Commission dedicated to the Cunit project in 1844, the Prefect Pellenc concluded in an 1847 letter to the government that "a straight un-submersible embankment will prevent flooding and lateral draining channels will sanitise the plain" and that "in the presence of [an] imminent danger [...] threatening State interests themselves, the Government cannot hesitate anymore." However, Mr. de Monteynard pointed to "numerous oppositions to the project" in the 3-year analysis of the Prefect Pellenc Commission (Appendix A-n°5). When a new public consultation was launched in April 1851 (Appendix A - n°7), the project emergence met more contestation than cooperation. It generated great tension with open critics of the Prefect in the press (Appendix A n°13) and personal hostility against Engineer Cunit, who was accused of partiality in a letter asking not to let him analyse the consultation (Appendix A - n°9).

We illustrate below how the actors involved in the project's development tended to negotiate their positions and contest alternative imaginaries. In previous literature, the City of Grenoble's opposition has been presented as the central explanation for the meander's survival of only 20 km over the 120 km of the Isère River embankment (Belleudy, 2007; Agard, 1942, p. 186; Oumin, 1961). In the middle of the 19th Century, the city opposed the upstream straightening of the river, fearing an increased flood risk (Agard, 1942). The meanders were considered upstream storage that delay and reduce floods in the downtown area of the city where the efficiency of the river embankment was discussed. As a simple matter of interest, Grenoble logically adopted the opposite position about the meanders for the dikes of the Drac River and the downstream Isère River, fearing backwaters at the confluence. In a sense, the city had a modernist point of view downstream and an anti-modernist one upstream.

The most consistent arguments against the project came from the riparian owners of the upstream part of the Grésivaudan Valley (roughly upstream of Lancey), where the embankment was already advanced. Under the impulsion of the Mayor of the municipality of Barraux around 1810, the Unions and construction contractors built a consistent line of dikes over ca. 8 km from La Gâche to Sainte Marie d'Alloix. The communities of this already embanked area suffered less from the Sardinian project. Their position was developed in a pamphlet about the Cunit project that was edited by Mr. Duchesne, a rich landowner in the Upper Valley who was in charge of the Union of Crolles (Appendix A-n°10). Having tried for over 50 years to build enough dikes to develop and protect newly cultivated lands, he refused to unite with downstream communities in one union over concerns about contributing to the construction of downstream dikes; in other words, he refused to pay twice. In addition, his position was clearly against lateral channels and the construction of new dikes before stabilising the river bed - a "wait and see" position. This private initiative well-reflected the position of many landowners collected in petitions circulated among municipalities (Appendix A - n°8). For instance, the municipality of Crolles recognised that the valley was not drained, but would care about lateral channels if the straightening of the river and the continuity of the dikes were not enough.

The Duchesne initiative met the opposition of Mr. Jacquemet, another rich landowner but from the Lower Valley, who wrote a letter to the Prefect (Appendix A - n°11). Jacquemet's argument was twofold and somewhat contradictory. Referring to the experience gained from the Drac River embankment, he was against straightening, which would be costly and insufficient to evacuate the sediments. On the other hand, he asked for the contribution of the Upper Valley landowners who would benefit from the suppression of backwater problems if the Lower Valley straightening was realised. Regarding Jacquemet's initiative, the position of the Lower Valley landowners as collected in petitions was more diverse than upstream. Villard-Bonnot, a municipality on the left bank of the river, globally approved the project and sustained Cunit but asked to postpone the lateral channel construction until the river stabilised

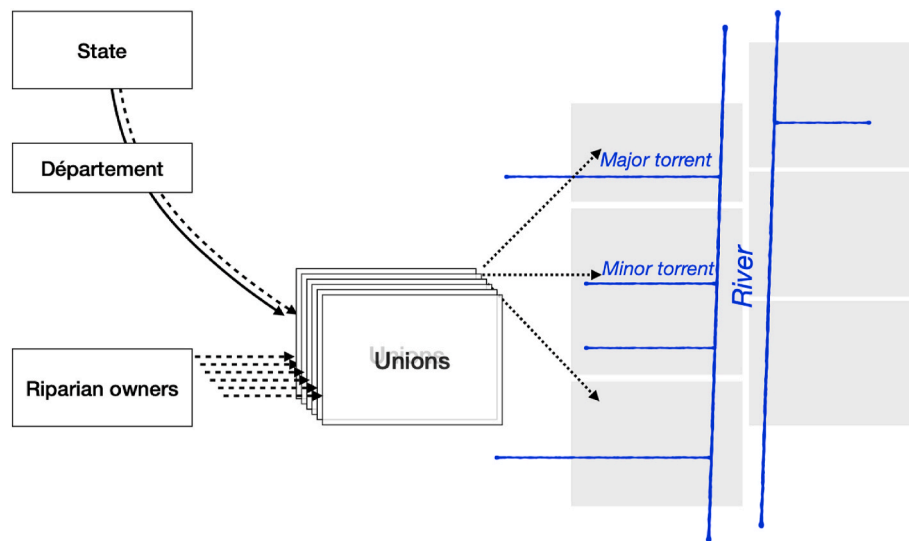


Fig. 3. Schematic presentation of the legal arrangement of the flood infrastructure management around 1850 and of the tessellation of the river system by the Union's perimeters.

Legend: The left part of the graph (in black) links actors and institutions describing the project supervision and control (block arrows), the project funding (dashed arrows) and the infrastructure management (dotted arrows). The right part of the graph (in blue) sketches the river system. The management perimeters (grey rectangles) basically oppose the river banks and follow torrential tributaries. Large and small torrents are naturally connected to the river. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Source: construction of the authors, 2023

(Appendix A - n°8). Gières, another municipality on the left bank, also approved the project but argued about how to straighten the river. They asked for a modification of the track, giving more space to the municipality and triggering the opposition of the municipality of Meylan on the right bank (Appendix A - n°12). More generally, the same survey mentions exhausted landowners after a decade of severe floods, burdened with debts, fearing land expropriation and, in turn, refusing to put effort into a global project and its single Union (Appendix A - n°20). Only boat transporters immediately favoured straightening, seeing their interest in having a smoother and much shorter way to travel and benefitting from a better path on the bank (Appendix A - n°6).

Last but not least, the opposition to the project also came from fluctuations between expert views. The letter of the Principal Engineer de Montrond to the Consultation Commission (Appendix A - n°14) is a good illustration of such fluctuations that inspired what de Monteynard calls “a great incredulity [of the public] to scientific assertions” (Appendix A - n°20). Mr. de Montrond was in charge of the Grésivaudan Valley before he left the position to Cunit in 1847 and was promoted in Ardèche, a nearby department. Cunit criticised him in the project report for changing his mind from in-submersible to submersible dikes just before he left. Mr. de Montrond explains that he realised late the harmfulness of what he calls “narrow embankment,” observing since 1838 on embanked segments that, unexpectedly, the raising of the riverbed height instead of the opposite. Apart from de Montrond, other authorised voices promoted alternatives to the Cunit solution during the consultation. For instance, the Prefect Councillor Durand-Lainé who promoted a double fence of dikes with a first row of submersible dikes and a large width for flood expansion behind since 1840 (Appendix A - n°15).

Beyond the emerging counter-imaginaries evoked above that certainly contributed to the administrative blockage of the project, “the almost unanimous lamentations about the financial difficulties of dike constructors” described by de Monteynard (Appendix A - n°20) is a central factor of the project's failure. Two major floods touched the valley in August 1850 and 1852; their impact on farming pushed people to mention in petitions that many were exhausted and ruined. The Prefect asked the Government in March 1852 to adopt the project, but after several procrastinations, the Minister explained in May 1854 that “this

affair raises serious difficulties in the presence of many reclamations” (Appendix A - n°23).

From there, the straightening of the Isère River remained unachieved. In 1861, after the major flood of November 1859, and given the initial difficulties of implementation, the State Engineer Gentil went back to quite the opposite imaginary of submersible dikes of Durand-Lainé (Appendix A - n°15), and promoted that the meanders were no longer an issue (Agard, 1942). The economic cost of the infrastructure was minimal since the disparate dikes built thanks to the partial merging of the Unions were almost sufficient, and the plans were easy to design. This new project was not implemented because financing rather went towards drainage works (see Section 6). Nevertheless, this hesitation in the range of a decade between two opposite visions sent a negative signal that the straightening appeared optional or, at least, expert-dependent.

4.3. Contested imaginaries and meanders resisting the straightening of the river

The source of this first SMF example is thus a complex opposition merging technical and societal considerations that can be interpreted as a conflict between competing imaginaries and associated interests. The City of Grenoble and small rural communities, put their local interests ahead of the Nation's. More surprisingly, even within the State administration, the Modernist imaginary was not universally shared. Some engineers preferred to negotiate their project locally rather than impose a solution. This SMF triggered over the course of a decade, starting around 1850. These resisting meanders along an imagined straightened river survive still today, obviously putting into question what the valley would have been without this conflict of imaginaries.

This example illustrates the normative and prescriptive dimension of imaginaries in competition about how territories should be organised and how their inhabitants should live (Hommes & Boelens, 2017). It also shows the complex relations linking the transformation of imaginaries and infrastructures, that led in the recent years to the reverse process of re-meandering the river, at least during flooding events. Petersson (2021) considers the dismantling of infrastructures. In our case study, the dikes are not dismantled but locally “erased” during floods in order

to use the ancient meanders as retention basins. We show as well, that different imaginaries are always in spatial competition within the same HST, including within the State.

5. A second socio-material fracturing: legal pluralism and its effects on river oversight

Until the Revolution of 1789, France lived in a situation of legal pluralism (Poumarède, 2009), i.e., a situation in which different legal orders (Griffiths, 1986) based on different sources of law coexisted, and where "the social reality of law [was] expressed outside as well as inside the state organization" (Belley, 1986, p. 1). Officially, the French Revolution ended this legal pluralism and imposed the State as the only legitimate source of law. However, in practice, situations of legal pluralism persisted.⁴ This was the case with the right to intervene in watercourses, which is essentially a community right and originates in Roman and natural law distinct from the State (Brochet & Renou, 2021).

5.1. Legal pluralism and the old unions of riparian owners

In the Grésivaudan Valley, riparian owner's unions were already present during the Middle Ages to deal with flooding issues (Brochet & Renou, 2021). These unions produced their own norms, according to their own common legal order, and were preserved after the French Revolution. At the beginning of the 19th century, they had not yet been incorporated into modern positive law. As a result, the French State and the unions simultaneously had a legitimate right to act on the flood issue. This situation gave rise to legal pluralism and made it difficult to articulate these norms from different legal orders.

Unions were first incorporated into positive law in 1807, but only partially. The Law of September 16th, 1807, instituted a marshland drying policy, and at the same time, officially recognised the unions' responsibility for flood protection works. However, in its article 27, the law states that:

"The conservation of drying works, that of dikes against torrents, streams, rivers and on the shores of lakes and the sea, is ruled by the public administration".

The riparian owners must ensure, or at least contribute to the protection against the natural action of water (Art. 33):

"When it comes to building dikes at sea or against navigable or non-navigable rivers, streams and torrents, the need will be confirmed by the Government, and the expense borne by protected property, in proportion to their interest in the works; except in those cases where the Government might consider it to be useful and fair to provide relief with public funds."

The legal system for flood protection that was being put in place resulted from a hybridisation between the ancient legal order of the unions and the new State legal order, which was entrusted with controlling them. This ambiguity made it difficult to implement Engineer Cunit's project.

5.2. The unions' reception of the Cunit project

When the Project started, a myriad of unions managed the waters on the French part of the Isère River. According to the Prefect Chapuys-Montlaville (Appendix A - n°13), the dikes of the Upper Grésivaudan were surveyed by 30 Unions, among which 18 were formal, and two

⁴ The State process of codifying the law undertaken in the 19th century took time and integrated whole swathes of Ancien Régime (i.e., pre-Revolution) law from different legal orders without redefining them. These laws from different legal orders have often been artificially attached to the categories of public and private law when they were codified. Though this integration process is now largely complete, recent studies document new situations of legal pluralism in France (Lavorel, 2007; Nicolau & Hourquebie, 2014).

were private landowners. In contrast, among several unions in the Lower Valley, most were dissolved for inactivity and only six still conducted work at their own expense (Agard, 1942, p. 735). The granularity of these unions was linked to the granularity of villages, as is in their names. As most villages are installed on torrential alluvial fans, each union manages a main torrent and also oversees its confluence with the river and the river dikes, if any, on their river bank.

In brief, the unions were designed to manage the river by segments and banks, in a sense, carving the two infrastructure levels, river dikes and artificial confluences, over a space segmentation of the two banks of the river. Fig. 3 summarises the legal arrangement of torrent and river management around 1850. However, this flood legal system preserving the unions' normative autonomy was not prepared to support an integrated vision of the project as promulgated by the State legal order. As a result, the presentation of the Cunit preliminary project faced a forest of institutions and individuals with no appropriate forum to debate among diverging imaginaries (see Section 3).

The inherited fragmentation of responsibilities between the French State and unions gives a first angle of analysis as to why the project was implemented differently than it was defined by the Engineer Cunit who defended the idea of a single, modern institution in charge of implementing the project. In other words, legal pluralism prevented the Cunit project from being carried out. That is, the unions do not recognize the legitimacy of the State based on their own legal order, and reject the Cunit project.

After the great floods of the Rhône, Loire and Garonne Rivers in 1856 (Coeur, 2004), the flooding problem was subject to more regulations in France (Creutin and Sanseverino, 2022). For instance, the Law of May 28th, 1858 states that, *"The State will proceed to the execution of the works intended to protect the cities from flooding."* However, this law did not change the obligation of riparian owners and their unions. As a result, the role of two actors, the unions and the State, was still recognised and codified, maintaining the conflict of legal legitimacy between them.

The flood of November 1859 that majorly impacted Grenoble (Auffray et al., 2011; Pilot de Thorey, 1860, p. 131) invigorated the debate. After the visit of the Public Works Minister, the principle of merging the unions was accepted in exchange for the guarantee of substantial national funds for the dikes. On October 18th, 1862, a decree constituted nine large riparian owner's unions in which the multiple unions must merge (Agard, 1942). From the promulgation of the decree, it took fifteen more years of negotiations with the owner's unions to determine the perimeter of the nine unions. In terms of granularity, this reunion of unions allowed the movement from the management of one to several torrents (typically 3–4) and included the Chantournes as manageable objects. The management of the river itself remained fragmented along segments of the river course and by bank.

5.3. The decree of 1936, the ADIDR and the scaled river

In the 1920s, the nine large unions were still struggling to coordinate among themselves, and the Project was in crisis. The level of realisation of the infrastructure was heterogeneous, depending locally on the dynamism and resources available within each union. In front of this crisis evoked in Section 5, an inter-ministerial commission approved the Schneider Project in 1929 (Appendix A - n°33) and suggested creating a new institutional level of coordination (Brochet & Renou, 2021). The Association Départementale des collectivités intéressées à l'aménagement des plaines de l'Isère et du Drac (ADIDR) was implemented by decree on September 27, 1936 (Appendix A - n°35). According to the Decree, the role of this departmental institution was to conduct the homogeneous construction and maintenance of flood infrastructure, excluding the proposition of new projects. This new actor grouped the nine large existing unions of the Grésivaudan Valley, but its perimeter was much wider, covering the Drac and Isère basins, and its membership more varied, including namely the Isère Department, the City of Grenoble, 53 riverine municipalities, as well as numerous unions covering

the rest of the Department.

This new legal arrangement confiscated the unions' legal autonomy of the embankment and created a more administrative and *ad-hoc* assembly in accordance with the State legal order. With a focus on infrastructure and a wider hydrologic perimeter, this arrangement carved the management of the river, the torrents, and the chantournes in a new way that dissociated the two infrastructure levels. The management of the artificial confluence level remained the direct responsibility of riparian owners' unions, and the management of the river dike level was entrusted to the departmental institution. Fig. 4 shows how the confluence areas between the river and the torrents were split between two levels of management.

From this period, torrential confluences became friction areas in the middle of an implicit hierarchy between the protection of the river on the one hand, and the protection of the torrents and chantournes on the other. Each level of infrastructure having its own autonomous career, a new level of heterogeneity appeared between levels in addition to a pre-existing heterogeneity in space, each artificial confluence system taking specific configurations within each riparian owner's union. A consequence of this hierarchy was that it made flooding issues less visible at the artificial confluence level and eased the continuous urbanisation surrounding torrents and Chantournes, which remain areas at high risk of flooding (see Section 6).

5.4. Surviving unions puzzling together modern infrastructure management

The source of this second SMF example is in competing institutional norms and arrangements (Hommels, 2005) that enable the infrastructure to materialise. It is a question of understanding which actors are going to be competent to implement this project and on which

dimensions of the project. Two legal orders were superimposed, the public law of the State and that of local communities, alongside the progressive implementation of the Cunit project over more than a century. We draw here on the theories of legal pluralism (Eberhard, 2001; Griffiths, 1986; Vanderlinden, 1989), according to which two (or more) legal systems, or legal orders, can coexist in the same space. The State is not the sole holder of normative production, but is in competition with riparian owners, who produced their own norms, or even their own commons well before the project (Brochet and Renou, 2021).

Analysing the lifecycle of the infrastructure, we show how the infrastructure management evolved toward greater unity, resorbing to some extent the SMF. But the governance still separates the river into two independent levels, the legacy of which still persists in the imaginaries of present-day (Arik et al., 2023). This example illustrates the value of simultaneously studying the temporal and spatial trajectories of SHT (Cousins & Newell, 2015).

6. A third socio-material fracturing: when sediments rebel against the Cunit project

By the 1910s, the infrastructure proposed by the Cunit Project was only partially implemented, in great part due to legal reasons (see Section 4) as well as technical and practical controversies (see Section 6). An additional cause of the project extinction came from an external and quite unpredictable *agentive force* – sediments. The progressive implementation of the Cunit project, which narrowed the river channel, modified the bed-load transport conditions and introduced major disturbances of the sediment transfer processes. Sediment accumulation in the river threatened the efficacy of the infrastructure, which invigorated controversies.

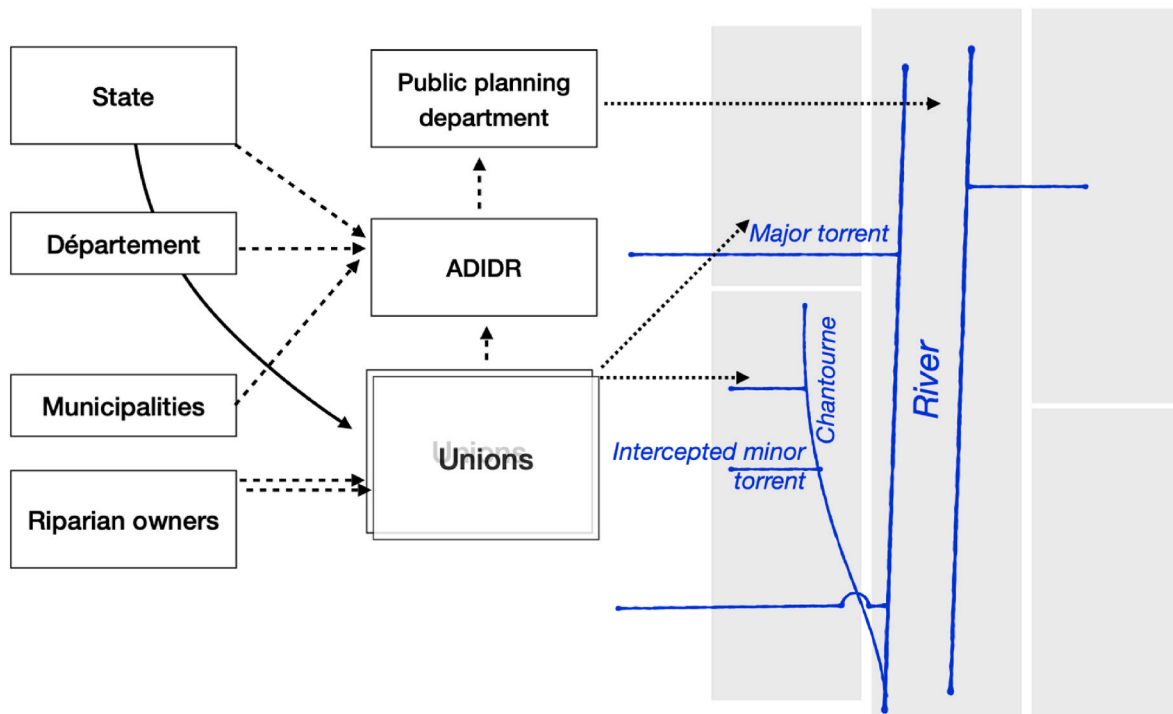


Fig. 4. Schematic presentation of the legal arrangement of the flood infrastructure management from 1936 and of the scaled fragmentation of the river system.

Legend: Same representation as in Fig. 3 with the management perimeters in grey. At the tributary level, fewer unions having larger perimeters cover the artificial confluence systems called chantournes. Small torrents are drained by the chantourne that connects to the river downstream. Large torrents are directly connected to the river, passing if needed over the chantourne (tunnel). At the river level, the management perimeter of the new public planning department disconnects the unions' perimeters from the river banks.

Source: construction of the authors, 2023

6.1. Sediments: an ill-thought-out infrastructure component of the Cunit project

The Cunit project was technically sound regarding water transfers thanks to the good hydraulic skills of the engineers at that time. However, major disturbances of sediment transfer on both sides of the dikes were not correctly predicted, even though some major changes were expected.

After a few decades, the embankment on the river side of the dike, even though partial, led to the vertical accumulation of sediments and transformed the Isère River into a perched river. The rise of the river bed limited the efficiency of the dike protection against floods, increasing the risk of overspill and breaches. In spite of the argument that in maintaining higher water velocities the embankment would minimize sediment deposit, the rate of deposition appeared much higher than anticipated, requiring more space devoted to the river. This ill-thought-out outcome brought back the controversy between de Montrond and Cunit about the “narrow embankment” (see [Section 3.2](#)). It’s worth noting that predicting river transport bedload rates remains a technical challenge today ([Gomez & Soar, 2022](#)).

In the artificial confluence system built between the torrents and the river on the land side of the dike, the sediment production of torrents turned out to be ill-considered as well. The major torrents that were connected to the river through the dike presented the same syndrome of sediment accumulation and perching as the river. Minor torrents created massive sediment accumulation issues into the quasi-flat lateral channels of the chantournes in which they ended their course. For torrents, part of the inadvertent outcome came from the action of torrential “correction” conducted by the Forest Administration that gave the illusion that torrential sediments were under control. The Forest Administration created the RTM Service (Restoration des Terrains en Montagne) in 1860 to control erosion in the headwaters of several highly sloping torrent basins. In terms of infrastructure, RTM built a number of small dams (typically several per torrent) to block sediment transport and hence to limit torrential incision ([Robin et al., 2003](#), p. 179).

The sediment accumulation, as well as the perched river and torrents, led to a rising water table and brought the return of stagnant infiltrated waters in the plain. In 1926, a quarter of the plain suffered from excess soil moisture, making it difficult to cultivate ([Blanic & Verdet, 1975](#)), harming agriculture and public health ([Belleudy, 2007](#), p. 186; [Appendix A - n°30](#), [Appendix A - n°28](#)). Farmers, who a few decades earlier had benefited from the combining effects of the draining of the plain and of a supply of sediments as fertiliser, were now faced with the sediment working against them. The lack of integration in the Cunit project of the mobility and inseparability of sediments from liquid water ([Lafaye de Micheaux et al., 2018](#)) is central to explaining the problems of soil moisture and flooding at the confluence zones. What we can call the “sediment rebellion” is still very little taken into account in social science research on water infrastructures ([Parrinello & Kondolf, 2021](#)).

6.2. The Schneider project as a response to the sediment crisis

In response to this crisis, the riparian owner’s unions carried out some works in the 1910s, like raising river dykes or recalibrating confluences. However, these efforts were largely insufficient to resolve the crisis. It also led the City of Grenoble to change its position about the meanders of the Lower Valley. From this crisis onward, the City followed the advice of State engineers and defended the idea of straightening the meanders to avoid the risk of exposing the city to a perched river.

In response to a demand of the Council of the Isère Department⁵ in September 1922, several technical reports published from 1922 to 1926

⁵ The Isère Department refers to the sub-regional administrative division of the State and a local authority.

analysed the sediment crisis in diverging ways. Broadly speaking, the State Road Engineers promoted river operations (e.g., dike rising, dredging - [Appendix A - n°26](#)) and the State Forest Engineers promoted upstream solutions (i.e., reforestation, torrent dams - [Appendix A - n°27](#); [Appendix A - n°25](#), [Appendix A - n°29](#)). A major flood in October 1928 showed a major lack of flow capacity and prompted a State reaction. Mixing these various solutions, Schneider Co., a private sector company (the largest French metal industry that had developed a civil engineering branch), offered an uncontested project ([D’Angio, 1995](#)). The Finance Law of July 27, 1930 engaged a new program ([Appendix A - n°34](#); [Decrop et al., 1997](#), p. 235) around the Schneider Project ([Appendix A - n°31](#); [Appendix A - n°32](#)). First defined in 1929, the Project was redesigned and, in great part, implemented after the flood of June 1948 when several levees failed. The French State largely funded this hydraulic infrastructure program that extended the ambition of the Cunit Project to sustain large-scale public efforts to fight against floods through the rest of the 20th Century. With this project, sediments were “transformed” from a threat to a resource, as they were needed to support the huge housing construction effort in the context of rapid urban development of the Grenoble Plain.

The main political objective was to preserve agricultural activity and promote the Grenoble agglomeration’s urban and industrial development in the context of strong population growth. Technically, the recommendation was to i) cut three remaining river loops and raise the un-submersible dikes in order to increase the water velocity, ii) install underwater sills to regulate sediment transport, iii) reinforce the lateral Chantourne drainage system and iv) allow sediment extraction from the bed contributing to building material needed for rapid urbanisation. The project conditioned the construction of various urban infrastructure, such as the highway that connects Grenoble to Chambéry ([Vivian, 1969](#)). It also accompanied the development of hydroelectricity dams by the national electricity company, Électricité de France (ÉDF), in the upper basins of the Isère and Drac Rivers between 1930 and 1970. Paradoxically, the Schneider project did not pay specific attention to the increasing vulnerability caused by Grenoble’s rapid urban and suburban growth behind the dikes, following the Winter Olympic Games of 1968.

Through this new project, the French State legitimised its role as a technical planner and main political protagonist of the HST. Its “Modern aspirations [were] generally characterised by a fascination for expert and engineering skills” ([Hommes et al., 2022](#), p. 4). Nonetheless, we can quote [Bruun \(2015: 23\)](#) regarding the outcome of this project: “The river turned into what we would readily recognize as conventional infrastructure, rather than a natural system. The river became a cyborg, an entity at once organic and machine”.

6.3. The Schneider project implementation: Where did the sediment go?

The Schneider project was implemented incrementally from the post-war years until the late 1980s. Reinforcement of the dikes was carried out gradually depending on available funding and spanned the entire period. The problem of sediments was treated during the late 1960s and early 1970s. Due to a lack of available budget, only one loop was ultimately cut at Bois Français in 1968 (see [Fig. 5](#)). Finally, in the 1970s, the chantournes were revamped.

The ‘corrections’ that were carried out by the Schneider project (e.g., straightening the bed, cleaning up, removing materials) to solve this sediment problem led to the apparition of opposite and new problems (i.e., lowering and draining the water table, hydraulic disconnection between torrents, chantournes and river) due to sediment scarcity ([Dawson, 2021](#)).

A central explanation to this new crisis comes from the authorisation that the French State gave to public works companies to dredge the river. This political choice that considered sediments as an economic resource was politically accepted in the context of the 1960s, which was marked by a very large need for materials, like sand and sediment, to build the Olympic city. This argument is supported by the fact that



Fig. 5. The construction of a channel to cut a loop of the Isère River known as the “Bois Français” in 1968.

Legend: This picture, shows the preparatory public works for cutting the Bois Français loop of the Isère in 1968. This picture perfectly illustrates the imaginary of the Modernist era, i.e. the idea to correct the natural imperfections of the river by straightening its water course.

Source: Symbhi’s archives

during this period, Grenoble was one of the cities in France with the highest population growth (Brochet, 2023, p. 90). This phenomenon, coupled with the development of hydroelectric dams upstream on the Isère River, led a request for sedimentary justice (Gorostiza et al., 2023). Indeed, the City of Grenoble strongly opposed EDF’s development work on the Isère and Drac rivers and the authorisations granted to companies to extract water and materials from the riverbed and the water table (Brochet, 2023, p. 95). A main reason was that these actions led to a drop in the level of the city’s drinking water supply and to occasional shortages. The City of Grenoble took legal action against EDF’s hydroelectric schemes. Local residents’ associations also sprung up around this issue (Brochet, 2023).

In the 1980s, other problems arose, this time related to sediment quality. The urban development of the plain and associated industries conduced to increasing pollution of sediments, turning them from a blessing for farmers into an environmental threat and sanitary issue.

6.4. Ignored sediment flow periling water control

The source of this third SMF lies in the mere fact that river flows are not just water flows but also sediment flows. In the field of water infrastructure, more research is incorporating the materiality of water into the analysis (Camargo & Cortesi, 2019). However, Parrinello and Kondolf (2021) and Lafaye de Micheaux et al. (2018) have pointed out that sediment is still inadequately considered in social science research on water infrastructures. Lafaye de Micheaux et al. (2018) have shown that flood protection infrastructure has a strong effect on sediment dynamics, producing sediment scarcity by trapping it behind dams or between dykes (Gorostiza et al., 2023; Lahiri-Dutt, 2014). Extracting and trading sediments also has profoundly unequal effects. The question of what infrastructure and human action do to sediments is therefore documented. Looking to the presence of sediments as a SMF led, in the opposite perspective, to ask what sediments did to the infrastructure. The sediments appear to be a “vibrant matter” (Bennett, 2010, p. 176),

an agentive force that reconfigured the flood protection infrastructure and that ultimately questions who benefits and who suffers from scarcity or abundance of sediments, a matter of “sedimentary justice” (Dawson, 2021). During the 1910s and 1920s, the sediment problem provoked a politicisation of the farmers of the plain who opposed the Cunit project. Indeed, by making the sediments immobile, the State engineers deprived farmers of exceptional fertiliser for their land and also transformed their land into marshy areas, compromising their harvests. The sediments thus lead to a SMF in Cunit project and permitted the emergence of the Schneider project, thus the opportunity and attempt to fix a new imaginary. In the second part of the 20th century, the sediments became an ally of the capitalist promoters of the modern industrial city and changed their nature, “from threat to asset” (Guerrin et al., 2021).

7. A fourth socio-material fracturing: When informal practices transform the initial function of the infrastructure – The chantourne as a Swiss Army knife

The chantournes are secondary infrastructure with a twofold role: to organise the confluence of minor torrents and to drain the lateral plain. Cunit rightly considered their absolute necessity as a complement to the dike, especially in a mountainous valley of numerous tributaries and where the plain is rigorously flat (Appendix A - n°6). This complementarity was difficult to understand by the riverine population, and perhaps not so clearly explained in the Cunit report that the Prefect was obliged in 1855 to edit in a note (Appendix A - n°24) detailing very didactically that the chantournes have two roles, being “Channels of derivation and drainage, often improperly called drainage channels”. The chantournes would not have been effective because there was a fundamental conflict between these two roles when moving from ordinary to exceptional times of extreme flows in rivers and torrents. During exceptional times, the role of the chantourne is very simple - convey the large flow of the torrents downstream into the river and prevent backwaters, which means a good design and careful maintenance of the flow

capacity of these channels and their link to the river. The chantourne is then a full part of the embankment system. During ordinary times, chantournes were initially designed for agricultural drainage, but as we shall see, other unplanned functions were gradually assigned to it, such as industrial or urban wastewater elimination, hence the image of a Swiss Army knife. We dissect below how the riparian owners and their Unions, who are responsible for maintaining this infrastructure, discover through experience the agricultural benefit of the chantournes and how this enthusiasm of ordinary times tended to modify the articulation between the two levels of the embankment infrastructure.

7.1. The chantourne: From a flood canal derivation to an agricultural infrastructure

Following the recommendation of the Chief Engineer Picot (Appendix A - n°17), the construction of the first Chantourne from Lancy to Domène (Channel n°5 of the left bank - the so-called Cheminade Channel) started in 1854 (Appendix A - n°19). The Cheminade Channel was a flourishing and enthusiastic success. The drainage of this confluence zone was so effective that the vast wetland was transformed into fertile land, allowing this part of the Lower Valley to experience unprecedented agricultural prosperity. Farmers could cultivate new land and crops (Miège, 1951) and experienced exceptional development of their farms. In addition, constructing a chantourne was a concrete motivation for the French State to merge riparian owner's unions.

The experiment of Cheminade Channel motivated the development of other chantournes, notably on the opposite bank where the plain is more extensive. From Saint-Ismier to Grenoble, the construction started in 1869. Still, its upstream extension met with strong opposition that progressively disappeared thanks to successive experiments, in a sense proving the concept, segment after segment (i.e., Saint Ismier in 1873, Saint Nazaire in 1880 and Le Touvet in 1891) (Agard, 1942).

The segmentation of the river oversight into several unions and the asymmetry between banks with a large (right) and a narrow (left) lateral plain led to considerable heterogeneity in the quality and efficiency of these artificial confluences from one channel to the next. For example, the Saint-Ismier chantourne (right bank) was made of poor-quality concrete frames and is poorly calibrated and interconnected. Meanwhile, the chantourne from Tencin to Lancy (left bank) was well-dimensioned and well-built. Nevertheless, this drainage network brought continuous prosperity until WWI and the sediment crisis (see Section 5.1). The everyday practices of the farmers of the plain fully adapted to this new infrastructure, which enabled their economic development. Nevertheless, between 1914 and 1950, the chantournes experienced a constant decline through progressive infill and erosion due to a series of 9 floods that the river embankment could not control (Appendix A - n°37). Subsequently, the chantourne system collapsed over 30 years, undermined by post-war inflation, a farm production drop linked to the return of water infiltration, the lack of a dedicated workforce (instead attracted to industry jobs or the international concurrence on hemp and silk), and lack of funding from the unions collecting insufficient taxes for maintenance (Agard, 1942; Appendix A - n°37).

With this succession of experiments, and despite these circumstantial difficulties, we observe that the unions were primarily trained by short-term practices of agricultural production. They steadily invested their interest and efforts in the channels more than in dike construction. The long period of calm in the Grésivaudan Valley between the floods of 1859 and 1914 reinforced the doubt regarding the necessity of dike protection. The incapacity to conduct the successive dike programs, as well as the purely agricultural practices of chantourne users, progressively pushed the experts and the politics starting in the 1930s to see the chantournes as agricultural drainage more than artificial torrent confluences flood infrastructure. They engaged a split in the regulatory scheme with a super-institution, the ADIDR, in charge of dike maintenance and local unions in charge of the drainage of the Plain (Appendix A - n°34; see Section 4.3). De facto, they dissociated the two levels of

infrastructure.

7.2. From agricultural to urban water infrastructure

This change of vision was marked by a shift in the State Corps of Engineers and by the project motivation. After failed attempts to fund the Schneider Co. project in 1930 (Appendix A - n°34) and during WWII (Appendix A - n°36), the chantourne system was completely rebuilt under the umbrella of the Ministry of Agriculture. The central argument of the project was to develop a large productive agricultural area of 140 km² (Blanic, 1974). The confluence aspect of the chantournes were indirectly present since torrents largely contributed to filling and blocking the channels during the sediment crisis. But there was no reflection about how to improve torrential flood water drainage beyond clearing the sediment cones and fans.

The urban growth and industrial development that steadily changed the sociology of the place over 1850–1950 (Bacconnet, 1956) considerably sped up after the 1950s and until the 1980s. Beside farming, new industrial plants and residential sectors often promoted varied usages of the chantournes (Belleudy, 2007, p. 186). The increased complexity of the urban network of channels and pipes, multiplying and crossing varied unplanned usages such as urban runoff and sewage collectors or energy lateral channels, accentuated the split between the river embankment and lateral infrastructures. These new functions attributed to chantournes were not planned rationally. The rainwater and wastewater networks were connected to the bypasses using “socio-technical tinkering” (Kemerink-Seyoum, 2019) and informal practices, in the absence of easily implementable alternative solutions.

With time, the next generations of engineers and city planners further artificialised the torrent and chantourne system to fit the urban infrastructure (e.g., roads, urban networks, etc.), particularly in the City of Grenoble and its neighbouring agglomeration. Torrent waters were increasingly disconnected from their original watersheds and pooled, mixed and concealed under the City before joining the river. The connection of torrents and urban waters to the river through electric pump stations appeared in the panel of solutions proposed by the Schneider Co. Project (Appendix A - n°32) in the early 1930s and was applied through the 20th century in various urbanised sectors. It can be considered the ultimate functional split between the river and the lateral infrastructure, where the continuity of water flow started to depend on devices needing external energy, without even taking into account the agency of the sediment (see section 5).

7.3. Autonomous Swiss-knife channels

The source of this fourth SMF lies in the practices of the beneficiaries of the infrastructure. The subjectivities and practices of the actors play a decisive role in the materialisation of hydraulic infrastructure project (Brochet & Guerrin, 2022; Le Visage, 2022) and reveal local processes of infrastructure appropriation (Aubriot, 2013; Mollinga, 2014; Valadaud & Aubriot, 2019). These ordinary, everyday practices (McFarlane & Silver, 2017; Mills-Novoa et al., 2020; Reckwitz, 2002; Schatzki, 2012; Steele & Legacy, 2017) have gradually and incrementally transformed the initial functions of the chantournes that were inseparably dedicated to flood protection and drainage in the imaginary of the Cunit Project. This fourth SMF evolved continually over the study period, highlighting the interaction between ordinary practices and the implementation of infrastructure projects, exemplifying numerous phenomena of negotiation, resistance, and contestation between State engineers and the local actors in charge of their implementation. We showed that these contested relationships (Boelens et al., 2019) lead to a bottom-up transformation of infrastructures, which ultimately leads to their autonomy.

8. Conclusion

This article brings attention to the nascent concept of “socio-material

fracturing” applied to flood protection projects of the Grésivaudan Valley, Grenoble, France, between 1850 and 1980. It explains how the arrival of Modernity in the Valley, with its main objective of making water economically “productive,” was not implemented to its full imaginary potential from several respects. It demonstrates why SMFs are more than just problems of implementation or incompleteness of projects. They also may appear from the enduring radical pluralism of local societies including human and non-human actants that resist homogeneity and remain diverse regarding value systems, legal orders, natural and infrastructural materials, practices, and imaginaries. The HSTs under study have always been in the grip of a power struggle, on the one hand between the State, which wishes to modernise the territory through infrastructure, and on the other hand, humans and non-humans that live in the territory and resist this injunction. In the end, despite their apparent fixity, infrastructures appear to be animated objects whose functions, spatial behaviour, and associated values evolve over time in relation to the complex interdependent dynamics of the HSTs. They forge alliances with human and non-human actors, resist certain injunctions, or disaggregate into diversified autonomous infrastructures.

The merit of studying SMFs is twofold: i) to understand the interaction both between the infrastructure project and the socio-natural characteristics of the HST in which it takes place and ii) to consider explicitly the dynamics of the project implementation, the so-called territorial fix. We summarise below how our study benefited from this twofold merit, considering successively the complexity and the dynamics of the problem at hand.

8.1. Under multiple forms and at different infrastructure levels, SMFs are by definition the norm in HSTs

Defining a SMF as a gap between the implemented infrastructure and the utopian plan (Hommes et al., 2022) puts the imaginary at the centre of the notion. The SMF is “measured” by the difference between the present state of implementation of a project and its founding imaginary. In that sense, in HSTs, SMFs are the norm rather than the exception, the implementation of a project never being ideal in many aspects and at various scales. Studying the same HST at a fine granularity, our analysis exemplified a variety of SMF forms able to divert the infrastructure from its initial functions (the chantournes that become agricultural infrastructures), to transform its spatial layout (the meanders that resist the riverbed straightening), to transfer the rights and responsibilities in relation to the infrastructure management to unforeseen actors (the effects of legal pluralism), or to merely abandon the project (the sediment role in the abandonment of the Cunit project).

Our analysis showed as well that SMFs do not necessarily concern the infrastructure as a whole, but may relate to one or more of its components at different levels, namely the i) geometry of the main embankment (meanders); ii) institutional relations (legal pluralism at different levels of management); iii) hydrology of the global system (sediment crisis at all levels); and iv) vocation of lateral channels (chantournes). These SMFs occur from many different sources including the presence or emergence of counter-imaginaries (large embankment for meanders), surviving norms (community management of infrastructures), material agentivity (sediments) or everyday practices (chantournes). They can be seen as the autonomisation of certain infrastructure components like dikes preferring to meander, confluence structures becoming units of management, or lateral channels changing their usages.

8.2. Arising, persisting and disappearing over time as imaginaries evolve, SMFs are definitely dynamic

Defining SMFs as alterations of the utopian plan (Hommes et al., 2022) gives a time dimension to the notion of SMF. A SMF does not mark a specific instant like an earthquake, but corresponds to a process of differentiation that operates over time. In our case study, we find various characteristics of differentiation that are summarised below.

A SMF process may start abruptly at the beginning of a project, which never lands in a virgin territory but is rather embedded in a pre-existing network of complex socio-natural relationships (Bruun Jensen & Morita, 2017). Our analysis of the Cunit Project showed, for instance, that pre-existing institutional relationships resisted the head engineer’s desire to entrust the global management of the infrastructure to public players. Instead, the shared management between public actors (via formal state legal order) and riparian owners (with regard to rights inherited from a community legal order) imperilled the homogeneity of the infrastructure construction. The same comment applies to the ideal of a straight river course of which a meandering river resisted from the very beginning and led to a constant redeployment of the State’s Project.

A SMF process may also start smoothly while the project appears to be on track. Indeed, over time, legislation, ideas about the relationship between nature and society, and scientific knowledge evolve. At the same time, infrastructure material deteriorates, opening up a window for fractures (Brewitt, 2019; Fox et al., 2016; Jørgensen, 2017). Our examples of SMFs showed how, over a few decades, the chantournes changed function, balancing multiple practices. We also showed how sediments degraded the performance of the system by a slow accumulation, flood after flood.

A SMF process may persist or reactivate over time as shown by the examples of legal pluralism and sediment rebellion. The State never abandoned its ideal of managing infrastructure through a unique public flood institution. However, despite repeated efforts of constant design and re-design of institutional relations, and despite modifications of the rationale of the head engineer, the infrastructure remained institutionally fragmented. On the other hand, the State realised the problem of the sediments and tried to solve the problem through the Schneider Project, without abandoning its ideal of hydraulic efficiency and without resorbing the SMF that persisted at torrential confluences. While the SMFs persist, the ill-functioning of the infrastructure gradually becomes the norm, a kind of negotiated compromise (Bolding et al., 1995) also seen as routinised incremental adjustments (Hidalgo-Bastidas & Boelens, 2019) or “socio-technical tinkering” (Kemerink-Seyoum, 2019). State infrastructure projects may thus appear in constant re-deployment (Bolding et al., 1995).

A SMF process may finally end, in general, with the evolution of the State project and a change of the associated imaginary (Swyngedouw, 1996, 2015, p. 301). As Hommes et al. (2022) point out, “as societies change, so do ideas of modernity and progress. Multiple modernities’ that have common overarching ideas but differential applications and interpretations, transform into new, hybrid configurations.” In our example of the river meanders, a counter-imaginary was gradually established about the protective effect of the meanders, which led to a very partial implementation of the initial project with the cutting of a single loop of the Isère in 1968 (i.e., more than a century after the project’s birth). This counter-imaginary has more recently become the norm, putting an end to the SMF. It was incorporated by the engineers themselves into the new Isère flood prevention project adopted in the early 2000s in the form of the Isère-amont project. This project uses the former flood plain, including the loop cut in 1968, as retention areas for flood protection (i.e., a complete reversal of perspective). The end of a SMF can also occur when dominant discourses and moral norms surrounding an infrastructure “are challenged or reinterpreted so that people’s repositioning with respect to the infrastructure becomes morally possible and legitimate” (Aubriot et al., 2018). In our example of the chantournes, the State never managed to completely frame the practices of plain farmers who have produced their own rationale about this infrastructure element that became a purely agricultural infrastructure, independent of the flood prevention project. The State then officially recognised the situation, passing the responsibility of chantournes to the Ministry of Agriculture, thus institutionalising the neglect of the essential component of the flood infrastructure.

At the end of this study, we can revisit the work of James C. Scott (1998, p. 464) to understand the dynamics of modernisation within

HSTs. Scott offered a history of “high modernist” regimes, noting that States have generally failed to meet people’s aspirations, despite sincere, welfare-inclined orientations. In our case, we saw how two infrastructure projects, guided by Modernist principles and intended to ensure the development of the HST of the Grésivaudan Valley, were largely altered by specific social and natural relationships. Scott implicates the State’s myopic and monolithic vision of nature and society, which only recognises formal, positivist, and epistemic knowledge. The myopia clearly points to a lack of intellectual insight to analyse the present state of the HST in its full socio-natural dimensions, and, to some extent, a lack of imagination to predict its evolution through a successful infrastructure project. Our four SMFs examples complement this view in many respects. The Cunit project appeared to be too confident in hydraulic science (using a vision of the river merely as a “highway” speeding up the water evacuation and ignoring sediment flow), and in modern law (negating the pluralism of local societies and implementing a simplistic vision of perfect rationality of infrastructure users).

According to Scott, the mobilisation of more modest forms of situated knowledge, closely linked to practical experience, would ultimately have proved more appropriate than the mobilisation of modern science. Or we can say that at least the State vision brought by the engineers could have better considered these forms of knowledge. This was the case, for example, of the Engineer de Montrond, who opposed the Cunit project on the basis of his own observations of the Isère floods and on what he learned from his longer presence in contact with local societies. We thus join Scott defending a planning design that recognises the local experience of beneficiaries.

In conclusion, the complex questions that arise are: i) how to govern “this uneasy compromise between ‘seeing’ and ‘not seeing’ like a State [where] its durability is doubtful” (Mayaux et Fernandez, 2024), and ii) how to defend a “cosmopolitical vision of the world” (Stengers, 2022, p. 632), with the objective of encouraging rather than combating “territorial hydrodiversity” (Brochet, 2017, p. 802). The socio-natural vision of Hydrosocial Territory, and more specifically the notion of Socio-Material Fractures appears to be a powerful tool to analyse this difference in “seeings” and perhaps to appreciate “hydrodiversity”.

CRediT authorship contribution statement

Antoine Brochet: Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Conceptualization. **Jean-Dominique Creutin:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Investigation, Conceptualization. **Aida Arik:** Writing – review & editing, Validation. **Yvan Renou:** Writing – review & editing, Validation, Project administration, Funding acquisition.

Submission declaration

The work described has not been published previously; is not under consideration for publication elsewhere; its publication is approved by all authors and by the funding source. If accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

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Declaration of competing interest

There are no known conflicts of interest associated with this publication, and there has been no significant financial support for this work that could have influenced its outcome.

Appendix A. Table of archives consulted and references at the Archives Départementales de l’Isère (A.D. Isère)

No	Title	Archive Reference
1	Mémoire du maire de Barraux relatif au redressement de l’Isère dans la vallée du Grésivaudan. 17 June 1804. Manuscript of 3 p.	A. D. Isère, 3 C 28
2	Mémoire présenté le 2 janvier 1847 à Mr le Préfet de l’Isère, par la Commission d’endiguement, à la suite des délibérations prises par cette Commission. Manuscript limited to its cover page in the present state of the archive (December 2023) - we thus rely on the transcription of Agard (1942).	A. D. Isère, 6 S 1/4
3	Arrêté de création d’une Commission Consultative pour l’endiguement de l’Isère du 20 novembre 1849 par le préfet Bordillon . Manuscript, 4 p.	A. D. Isère, 6 S 2/46
4	Propositions pour la constitution d’un syndicat unique et pour la fixation de son règlement d’administration publique, Préfet de l’Isère, 3 janvier 1850. Printed document, 18. pp	A. D. Isère, 6 S 2/46
5	Analyse de l’enquête (sur l’organisation syndicale) par une sous-commission: M. de Monteynard , rapporteur, 22 March 1850. Manuscript, 12 p.	A. D. Isère, 6 S 2/46
6	Endiguement de l’Isère et Assainissement de la vallée du Grésivaudan entre la frontière de Savoie et Grenoble: Avant-projet. C. Cunit , Grenoble, 6 août 1850, Printed In-quarto, Editeur Typographie Allier, 197 pp.	A. D. Isère, 6 S 2/47 et A. D. Isère, 6 S 2/46
7	Annonce des enquêtes sur l’avant-projet d’endiguement et le projet de syndicat unique. Chapuy-Montlaville , Official placard. 16 April 1851	A. D. Isère, 6 S 2/46
8	Extraits de la délibération du conseil municipal des communes de La Buissière, Gières, Meylan, Montbonnot, Murianette, Biviers, Domène, Saint Martin de Miséré, Saint Martin d’Hères, Le Versoud, Villard-Bonnot, Bernin, concernant le redressement et les canaux d’assainissement de la vallée du Grésivaudan. May 1851. Folder of manuscripts, ca. 100 p.	A. D. Isère, 6 S 2/47
9	Lettre de Fouillet, Vial, Goutier, Eyraud ... à Monsieur le Préfet. Not dated but mentioning the consultation. Manuscript, 4 p.	A. D. Isère, 6 S 2/47
10	Examen du projet d’endiguement de l’Isère et d’assainissement de la vallée du Grésivaudan de M. Cunit, par M. Duchesne . 10 June 1851. Printed Folio, Imprimerie Redon, 51 pp.	A. D. Isère, 6 S 2/47
11	Lettre de Jaquemot , propriétaire à Saint Martin de Miséré et Saint Ismier à Monsieur le Préfet. July 1851. Manuscript 10 p.	A. D. Isère, 6 S 2/47
12	Copie d’enquête pour le redressement de l’Isère. Comparution de divers propriétaires de Gières. 11 July 1851, Manuscript of 2 p. and 1 map	A. D. Isère, 6 S 2/47
13	Chapuy-Montlaville (Préfet de l’Isère). — Endiguement de l’Isère et Assainissement de la vallée du Grésivaudan entre le pont de Brignoud et la ville Grenoble: Propositions pour la constitution d’un syndicat unique et pour la fixation de son règlement d’administration publique Grenoble, 1851, Printed Folio, 17 pp.	A. D. Isère, 6 S 2/47 et A. D. Isère, 6 S 2/46

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(continued)

No	Title	Archive Reference
14	Lettre et mémoire de M. de Montrond à l'attention du Président de la commission d'enquête pour l'endiguement de l'Isère entre Brignoux et Grenoble. Not dated but a direct answer to Cunit's Report. Manuscript letter, 1 p. and report, 19 p.	A. D. Isère, 6 S 2/47
15	De l'endiguement de l'Isère. Durandlainé , Conseiller de Préfecture. Not dated but in response to Cunit Project. Printed notice, Imprimerie Baratier, 2pp.	A. D. Isère, 6 S 2/47
16	Rapport de l'ingénieur en chef à la suite de l'enquête sur l'avant-projet des travaux à faire pour l'endiguement de l'Isère entre la frontière de Savoie et le pont de Brignoud. Picot . 30 January 1852. Manuscript Folio, 11 p.	A. D. Isère, 6 S 2/46
17	Rapport de l'ingénieur en chef à la suite de l'enquête sur l'avant-projet des travaux à faire pour l'endiguement de l'Isère entre le pont de Brignoud et Grenoble et sur le projet de constitution des intéressés en une seule et même association syndicale. Picot . 11 March 1852. Manuscript Folio, 13 p.	A. D. Isère, 6 S 2/46
18	Pétitions à Mr le Ministre des Travaux Publics suite aux enquêtes ouvertes pour l'examen de l'avant-projet de Mr. Cunit relatif à l'endiguement et à la canalisation générale de la vallée d'Isère. May 1852, 3 manuscripts of 33 p., 20 p. and 21 p.	A. D. Isère, 6 S 2/47 (Fond Cunit-Berthon)
19	Arrêté préfectoral d'expropriation du 5 mai 1852 pour les communes de Villard Bonnot, du Versoud, de Domène et de Murianette. Manuscript, 4 p.	A. D. Isère 6 S 7/45/1
20	Rapport de la sous-commission ou analyse des pièces de l'enquête, B. de Monteynard , secrétaire de la commission. 16 August 1852, Manuscript 15 p.	A. D. Isère, 6 S 2/46
21	Etude d'une modification de l'avant-projet du chemin de fer de Grenoble à la Frontière Sarde. Alphonse de Charlary et Xavier-Célestin Vausse , Domène, 15 février 1853. Printed Folio, 15 pp. and 1 map.	A. D. Isère, 6 S 2/46
22	Pétition des membres du Conseil Général et du conseil d'arrondissement, des Maires et Adjoints et des Syndics Directeurs des digues de la vallée du Grésivaudan en amont de Grenoble tendant au déclassement des terrains du littoral stérilisés par les inondations de l'Isère à S. M. Napoléon III, et Déclaration de MM. Perrard , de Miribel , Laforte , Buisard . 25 January 1854. Printed Folio, 17 pp.	A. D. Isère, 6 S 2/47
23	Lettre du ministre au préfet et réponse. 20 May and 31 August 1854. Manuscript Letters, 3 p.	A. D. Isère, 6 S 2/46
24	But et caractères spéciaux des canaux de dérivation et d'écoulement des filtrations et nature des travaux dits d'assainissement, 15 September 1855, Mr le Préfet de l'Isère. Printed Folio, Imprimerie de Prudhomme, Grenoble, 3 pp.	A. D. Isère, 6 S 2/47
25	Rapport au Conseil Général sur les travaux de défense contre les inondations de l'Isère. Hullin ingénieur des Eaux et Forêts, le 21 octobre 1922. Typed A4 report.	A. D. Isère, 6 S 2/113
26	Rapport au Conseil Général sur l'aménagement de l'Isère en vue de l'assainissement de la plaine du Grésivaudan des ingénieurs Houpeurt - Guyon-Gellin des Ponts et Chaussées le 17 mars 1923. Typed A4 report. 12 p.	A. D. Isère, 6 S 2/113
27	Rapport au Conseil Général sur la création d'un canal latéral à l'Isère. Hullin ingénieur des Eaux et Forêts, le 29 octobre 1924. Typed A4 report.	A. D. Isère, 6 S 2/113
28	Comment sauver la plaine du Grésivaudan. Une étude de M. Bois, ingénieur des ponts et chaussées. Journal paper in "La Dépêche". 2 April 1925.	A. D. Isère, 6 S 2/113
29	Rapport au Conseil Général de l'ingénieur en chef des Eaux et Forêts Pampelone relatif au dragage du lit de l'Isère le 24 juillet 1925. Typed A4 report.	A. D. Isère, 6 S 2/113
30	La vallée du Grésivaudan en péril. Journal papers in "Le sud-est" Bulletin mensuel du conseil départemental d'agriculture de l'Isère. H. Roy , October 1926 p. 375–378 and November 1927 p. 412–414.	A. D. Isère, 6 S 2/113
31	Mémoire justificatif de l'avant-projet des travaux d'aménagement du système d'endiguement et d'assainissement des plaines de l'Isère, du Drac et de la Romanche - Consistance de l'avant-projet. Bénézit et Tumerelle , Schneider et Cie le 31 janvier 1929. Typed A4 report. 38 pp.	A. D. Isère, 12 S14/1
32	Mémoire justificatif de l'avant-projet des travaux d'aménagement du système d'endiguement et d'assainissement des plaines de l'Isère, du Drac et de la Romanche - Exposé général. Bénézit et Tumerelle , Schneider et Cie le 31 janvier 1929. Typed A4 report. 38 pp.	A. D. Isère, 12 S14/1
33	Lettre du ministre au préfet approuvant le projet Schneider. 12 July 1929. Typed A4 Letter, 2 pp.	A. D. Isère, 12 S14/1
34	Loi du 27 juillet 1930 relative à l'exécution de travaux d'aménagement du système d'endiguement et d'assainissement des plaines de l'Isère, du Drac et de la Romanche (Grésivaudan et Oisans), Journal Officiel de la République Française du 29 juillet 1930. p. 8563.	https://www.legifrance.gouv.fr/
35	Décret du 27 septembre 1936 portant règlement d'administration publique pour l'organisation de l'association des Intéressés aux travaux de défense et d'assainissement des plaines de l'Isère et du Drac dans le département de l'Isère, Journal Officiel de la République du 5 octobre 1936, p. 10558.	https://www.legifrance.gouv.fr/
36	Loi no 4834 du 30 novembre 1941 sur l'aménagement et l'assainissement des plaines de l'Isère, du Drac et de la Romanche (Grésivaudan et Oisans). Journal Officiel de la République Française du 2 décembre 1941. p. 5161-5162	https://www.legifrance.gouv.fr/
37	G. Oumin : Rapport historique de l'aménagement hydraulique de l'Isère, Ponts et Chaussées, Département de l'Isère, Service spécial de l'Aménagement de l'Isère. July 1961. Typed Report, 19 p.	

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