

To dam or not to dam in an age of anthropocene: Insights from a genealogy of media discourses

Silvia Flaminio^{a,b,*}, Hervé Piégay^a, Yves-François Le Lay^a

^a Université de Lyon, UMR 5600 EVS CNRS, ENS de Lyon, Site Descartes, 15 parvis René Descartes, F-69342 Lyon Cedex 07, BP 7000 France

^b Université de Lausanne, Institut de géographie et durabilité, Faculté des géosciences et de l'environnement, Géopolis - CH-1015, Lausanne, Switzerland

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ABSTRACT

Numerous studies have highlighted the negative consequences of dams (long-term alterations of Earth systems and social and economic injustices), and have questioned the sustainability of dams, i.e., the capacity of dams to meet the social, economic, and environmental needs of the current generation without compromising the needs of future generations. After having stalled in the 1990 s, dam construction has entered a new period of growth. Recent research has shown that this new phase in dam building can be explained by the promotion of hydropower as clean energy. To clarify the continuing debate on the construction of dams, particularly on their impacts and sustainability into the future, this paper examines the discourses on dams within the public domain. We used a collection of newspaper articles published in *Le Monde* from 1945 to 2019 on dams that were planned and built throughout the world ($n = 1471$). Results show a rise of different discourses on water infrastructure, which with time deal less with positive technical appraisals and more with controversies. Since the mid-2000 s, new arguments are defended (green energy) and new controversial discourses on the social and economic sustainability of dams (bearability, equitability) have emerged along with environmental questions (greenhouse gas footprint). These discourses reveal different understandings of sustainability which increase the complexity of the debate on dams. Results from this study suggest a need for a stronger dialogue between the scientific and public domains on the impacts of dams. Knowledge transfer and exchange would be particularly beneficial on 'renewable energy' and 'green energy,' and alternative modes of governance regarding dams.

1. Introduction

During the past century, numerous dams have been built throughout the world (Roe, 2012), with purposes that include irrigation, hydropower, water supply, flood prevention and navigation. These hydraulic infrastructures interrupted the flow of water and created reservoirs upstream. Dam construction stalled during the 1990 s, leading some to conclude that the era of big dams was over (e.g., Graf, 1999; McCully, 2001). This decline may be explainable by the reduction of attractive sites for dams, by changing water paradigms (Gleick, 2000) and by the progressive adoption by the water sector of the principles of sustainable development (Allan, 2003), whereby the needs of the current generation are met without compromising the needs of future generations (Brundtland, 1987, p. 37).

Nevertheless, since the end of the 2000 s, dam construction has entered a new period of growth. Plans for 'mega-dams' (Best, 2019) and

for smaller dams (Fung et al., 2019) have multiplied, coupled with schemes for hydropower. Currently, 3700 major hydropower dams are planned or under construction in the world (Zarfl et al., 2015). Even so, the amount of power produced, given the projected growth demand, is likely insufficient to replace non-renewable electricity resources (Zarfl et al., 2015). Such a rebound in dam-building raises environmental questions that are both social and ecological. It feeds the scientific debate on long-term environmental degradation in the context of global environmental change, especially within an anthropocene era of accelerated human interactions with Earth systems (Chin et al., 2013). The consequences of constructing dams remain diverse (e.g., social, economic, ecological, and geomorphological), at different scales (local, corridor, regional, and even global) (Baghel and Nüsser, 2010; Gross, 2016; Skalak et al., 2013; Williams et al., 2014; World Commission on Dams, 2000). As numerous studies have demonstrated, dams have profoundly affected flow conditions, channel morphology and river

* Corresponding author at: Université de Lyon, UMR 5600 EVS CNRS, ENS de Lyon, Site Descartes, 15 parvis René Descartes, F-69342 Lyon Cedex 07, BP 7000 France.

E-mail address: silvia.flaminio@unil.ch (S. Flaminio).

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ecosystems (e.g., Power et al., 1996; Poff et al., 1997; Rollet et al., 2014). They have even been described as an example of the “exploitation of Earth’s resources” which characterises the “Anthropocene” (Crutzen, 2002), and due to the drastic alteration of the world’s river systems they have caused, dams have been depicted as characteristic of the human domination of the Earth (Nüsser and Baghel, 2017). Recent research has shown that dams may not always be an advantageous option considering climate change. The reliance on reservoirs can worsen water and energy shortages (Di Baldassarre et al., 2018). Plans for hydropower dams in Eastern and Southern Africa, for example, will increase some countries’ dependence on hydroelectricity and therefore their exposure to the “risk of climate-induced electricity disruption” (Conway et al., 2017, p. 949). Moreover, not only can the resurgence of dam building lead to the disappearance of the last free-flowing rivers (Grill et al., 2019; Nilsson et al., 2005), the impact of climate change will also be greater on impounded rivers than on free-flowing rivers, which are expected to be more resilient (Palmer et al., 2008). Furthermore, during the past years, restoration ecology and other environmental fields have promoted dam removal to prevent further biodiversity loss and ‘reconnect’ watersheds (Magilligan et al., 2016). Among social scientists, debates regarding dam-building and the impact of dams are also strong, as they have shown how a new discourse on climate change and sustainability (Crow-Miller et al., 2017) is fuelling dam-building for hydropower or multipurpose reservoirs. Some states and institutions are framing hydroelectricity, for example, as renewable, ‘clean’, ‘green’ energy (Ahlers et al., 2015; Fletcher, 2010; Warner et al., 2017). Altogether, scholars in different scientific fields are questioning the sustainability of dams (Di Baldassarre et al., 2021).

To clarify the continuing debate on the construction of dams, particularly on their impacts and sustainability into the future, this paper examines the discourses on dams within the public domain. We focus on the public due to the relevance of dams on people’s lives, such as in relation to water resource management and energy production, and since the public often exerts political power for decisions concerning dam-building. We also focus on the public discourses on dams since the mid-20th century, because this period includes the peak in dam building and the development of controversies regarding the negative impacts of dams (Roe, 2012). In this paper, we therefore address the following research questions. First, how have the discourses and debates on dams, and notably on the sustainability of dams, developed within the public domain? Second, how can tracing a ‘genealogy’ of discourses on dams inform their sustainability into the future?

2. Approach, material and methods

2.1. General approach

This paper approaches the research questions with a Foucauldian perspective. Foucault promoted a ‘genealogical’ approach that examines “how series of discourse are formed [...]; what are their specific norms, and what are their conditions of emergence, growth and variation” and a critical approach that “distinguishes forms of exclusion, limitation and appropriation” (Foucault, 1971, p. 62–63). Accordingly, we investigate not only the genealogy of discourses relating to dams, but also the controversies at work during different periods. This post-structuralist framework invites us to question and highlight the emergence and the development of new discourses regarding dams. It also helps to reveal how older discourses may still be present and are adaptable to current issues. We consider a discourse is made of oral or written statements (Adger et al., 2001). It is also “a shared way of apprehending the world. Embedded in language, it enables those who subscribe to it to interpret bits of information and tie them together into coherent stories or accounts” (Dryzek, 2012, p. 9). Following Foucault, previous studies on water and hydraulic infrastructure have illustrated the role and power of discourse, and notably its political ramifications (e.g., Duarte-Abadía et al., 2015; Boelens et al., 2016; Boelens et al., 2019).

In a nutshell, the relevance of studying discourses is twofold. On one hand, the study of discourses allows documentation of the relationship between society and dams, because discourses materialise this relationship in oral and written statements. On the other hand, since discourses have a performative value, studying discourses also allows better understanding of how planning choices regarding dams are made, and more generally how “political decision-making takes place” (Hajer, 1995, p. 44). While studies in natural sciences have increasingly highlighted the ecological impacts of dams since the 1960 s (e.g., Scope, 1972), social sciences have often focused on controversies related to dam-building and their social consequences (e.g., Kaika, 2006; Hommes et al., 2016). Such research has focused on case studies situated in specific timeframes and socio-political contexts.

To consider more generally the public debate on dams and build a genealogy of discourses on dams, we used media as a primary source. Media capture the public domain well as places or forums in which individuals “engage each other about subjects of shared concern” (Pezullo and Cox, 2017, p. 20). Media and newspaper accounts also present many biases, as they personalise information, dramatise events, and tend toward novelty (Boykoff and Boykoff, 2007). Nevertheless, media play a role in political agenda setting (Downs, 2016) and reflect social concerns (de Loë, 1999). They are arenas among which new economic and environmental models can be produced (Burgess, 1990). Previous studies have highlighted the ‘centrality’ (Foxwell-Norton and Lester, 2017) of media in the communication of environmental issues and have recognised their value as a valid source to study environmental conflicts and as a stakeholder in environmental politics (e.g., Lester, 2010; Hansen, 2015). For these reasons, they can be valid for the study of environmental topics and controversies and their evolution over time. In other words, media allow study of the progression of “environmental issues in the public sphere” (Hansen, 2015, p. 217). In the social sciences and environmental studies, media sources have been successful to identify and distinguish different periods in water management on national scales (Wei et al., 2017, 2015).

In this study, we focus on both national and international news. This paper is based on media narratives from *Le Monde*, a French newspaper with a strong interest in international news and global socio-political debates (in a similar way to *The New York Times* or *The Guardian*). This source is particularly useful as *Le Monde* has digital archives dating back to the newspaper’s foundation in 1944. Although previous studies have largely relied on content analysis (Wei et al., 2017), we implemented a method based on textual data analysis (also often called ‘text mining’). This study therefore details the evolution of discourses on dams (between 1945 and 2019). It situates in time the integration of social, economic, and ecological issues within the debate on dams. We then discuss results within the international scientific literature and debates on dams into the future.

2.2. Material

We targeted the newspaper *Le Monde* for the history of the debate on dams, tracing the genealogy of discourses on dams and the framing of dams as sustainable levers. Although a French newspaper may suggest a Franco-centred perspective, *Le Monde* pays much attention to international news and its reporting considers different and often diverging points of view. It is also one of the few major daily newspapers with archives available in formatted text. Notably, it is accessible through university library subscriptions (through its website, www.lemonde.fr or through online platforms such as www.europresse.com). *Le Monde*’s archives go back to the newspaper’s foundation in 1944. Therefore, this source allows a longitudinal approach. Only a few other newspapers provide digitised archives over such a time span. For such reasons, *Le Monde* has been useful beyond francophone scholarship (Brossard et al., 2004).

2.3. Data collection

We combined different queries to avoid collecting articles that did not focus on hydraulic dams. The terms included “dam & river” (“*barrage & rivière*”, “*barrage & fleuve*”), “dam & lake” (“*barrage & lac*”), “dam & reservoir” (“*barrage & réservoir*”), “dam & licence” (“*barrage & concession*”). These queries produced over 6000 articles. Many duplicates were automatically excluded from the corpus. We then read and examined the articles individually. We excluded from the corpus articles that only briefly evoked dams. This process led to inclusion in the corpus of 1471 articles published between 1945 and 2019.

2.4. Data preparation

We collected and tabulated metadata on each article (publication date, author, article title). We also carried out a basic content analysis from the reading of the articles, focusing on information such as the dam site, the river or the river basin, and the country on which the article was centred. When the article only concerned one site, river, river basin or country, we also recorded this information in the metadata table. Moreover, for each article, we determined if the newspaper mentioned a controversy, i.e., an opposition or a disagreement between different stakeholders or communities involving the dam. Finally, using the scale elaborated by (de Loë, 1999), we determined whether the newspaper adopted a pro- or anti-dam tone, a neutral tone, and whether it presented both the pros and cons or simply whether the dam played a marginal role in the article.

2.5. Data analysis

To explore and analyse the data in the metadata table, we firstly summarised and plotted several key characteristics. The number of articles published per year, for example, identified periods of over and under news coverage. We also considered the evolution of dam building in the world between 1945 and 2020, based on the *World Register of Dams* (ICOLD, 2018), which represents dam builders and managers, and the International Commission on Large Dams (ICOLD), and which contained information on the building date of 51,514 dams throughout the world. After culling the data for the building of dams per year, we also measured the ratio between the dam coverage by *Le Monde* between January 1945 and December 2019, according to our corpus, and the total number of articles published each year in the newspaper. We further identified the countries and dams that benefited from a broad coverage by *Le Monde*: we were able to attribute countries to 1425 articles out of 1471.

Secondly, we performed a quantitative textual data analysis with the open-source programs Iramuteq (Ratinaud and Déjean, 2009) and TXM (Heiden et al., 2010). Textual data analysis, also often called ‘text mining’, is definable as a set of methods that rest on statistics to analyse text corpora (Beaudouin, 2016; Heiden et al., 2010). Iramuteq relies on R software and Python language to perform analyses such as the classification algorithm (Reinert, 1990, 1983), which comprises five main phases (Cottet et al., 2015). The classification algorithm proceeds through several steps. First, it segments the corpus into phrases (of 40 words approximately). Second, it lemmatises¹ the words using a grammatical dictionary. Third, it produces a contingency table between the lemma and other forms such as the metadata and the text segments. Fourth, it builds a top-down hierarchical classification based on the

contingency table (using χ^2 metrics). Fifth, it leads to the description of different lexical classes that present the degree of association between each class and the different forms (also using χ^2 metrics). Recent studies have used this method to identify discourses on different environmental subjects, such as invasive species (Cottet et al., 2015), rivers (Comby et al., 2019), and water conservation (Boyer et al., 2021). In this case, the classification algorithm allowed for the identification of 12 different lexical classes. We then considered the degree of association between the different classes and the decade of publication of the texts. We used the open-source data visualisation framework RAW Graphs (Mauri et al., 2017), and in particular the ‘area graph’, to represent the χ^2 for each class according to the different decades.

In parallel, we used the ‘progression’ function of TXM (which also relies on R statistical libraries) to examine the evolution of specific words and expressions within the corpus, according to the publication year of the newspaper articles. We produced graphs displaying the cumulative frequencies of different expressions such as “wild river” (“*rivière|fleuve sauvage*”) and “living river” (“*rivière|fleuve vivant*”) or “greenhouse gas” (“*gaz à effet de serre*”).

Thirdly, we conducted a qualitative and interpretative analysis. We read all 1471 articles comprised in the corpus. Based on the reading of the corpus and keyword searches performed in TXM, we identified quotes reflecting evolutions that we had previously statistically observed.

3. Results

3.1. Characteristics of coverage by *Le Monde*

The coverage by *Le Monde* was mostly strong during the main period of dam building throughout the world, i.e., between the 1950 s and the 1970 s (Fig. 1). The coverage was characterised by various peaks (e.g., 1952, 1959, 1982, 1990). The qualitative analysis allowed us to link some of these peaks to specific dam projects and controversies: the building of Tignes Dam in France received much attention in 1952; in 1959, *Le Monde* published a series of articles on the Malpasset disaster (Southern France); other peaks such as the 1982 and 1990 ones did not coincide with a single project event or controversy. After 1980, and during a period in which less dams were being built, *Le Monde* paid less attention to dams (Fig. 1). However, after 2010, the coverage of dams increased again.

Le Monde’s coverage was both international and Franco-centred. The corpus included 582 articles focused on France (40,1%). It also encompassed articles on 105 other countries (Fig. 2). Much attention was paid to dams planned or built in Egypt and China, and in particular to the Aswan High Dam (with some articles also focused on Sudan) and the Three Gorges Dam (Fig. 2).

3.2. From economics to livelihoods: twelve themes relating to dam-building (1945–2019)

Twelve major themes that relate to dams appeared in *Le Monde* (Fig. 3). Politics and geopolitics represented 1/5 of the newspaper articles’ content (classes 3, 5 and 10). Journalists also lengthily described the landscape and the populations affected by dam-building (classes 1 and 4). Technical characteristics of the infrastructures, rivers and lakes, also often appeared (classes 7, 11 and 12). Industry and economy, as well as the funding issue, were also topical issues (classes 2 and 9). Whereas environmental protests represented one of the smallest classes of the corpus (class 6, 6.5%), development and sustainability played a relatively important role in the articles (circa 8%). These themes related to discourses held on dams that have evolved through time.

¹ In linguistics, a lemma is generally defined as “a set of lexical forms having the same stem and belonging to the same major word class, differing only in inflection and / or spelling” (Francis and Kucera, 1982: 1). In general, a lemma is the standard dictionary entry of a word. To lemmatise means to tag words of a corpus according to their stem. In this case, the software we use matches each word of the corpus to a dictionary entry.

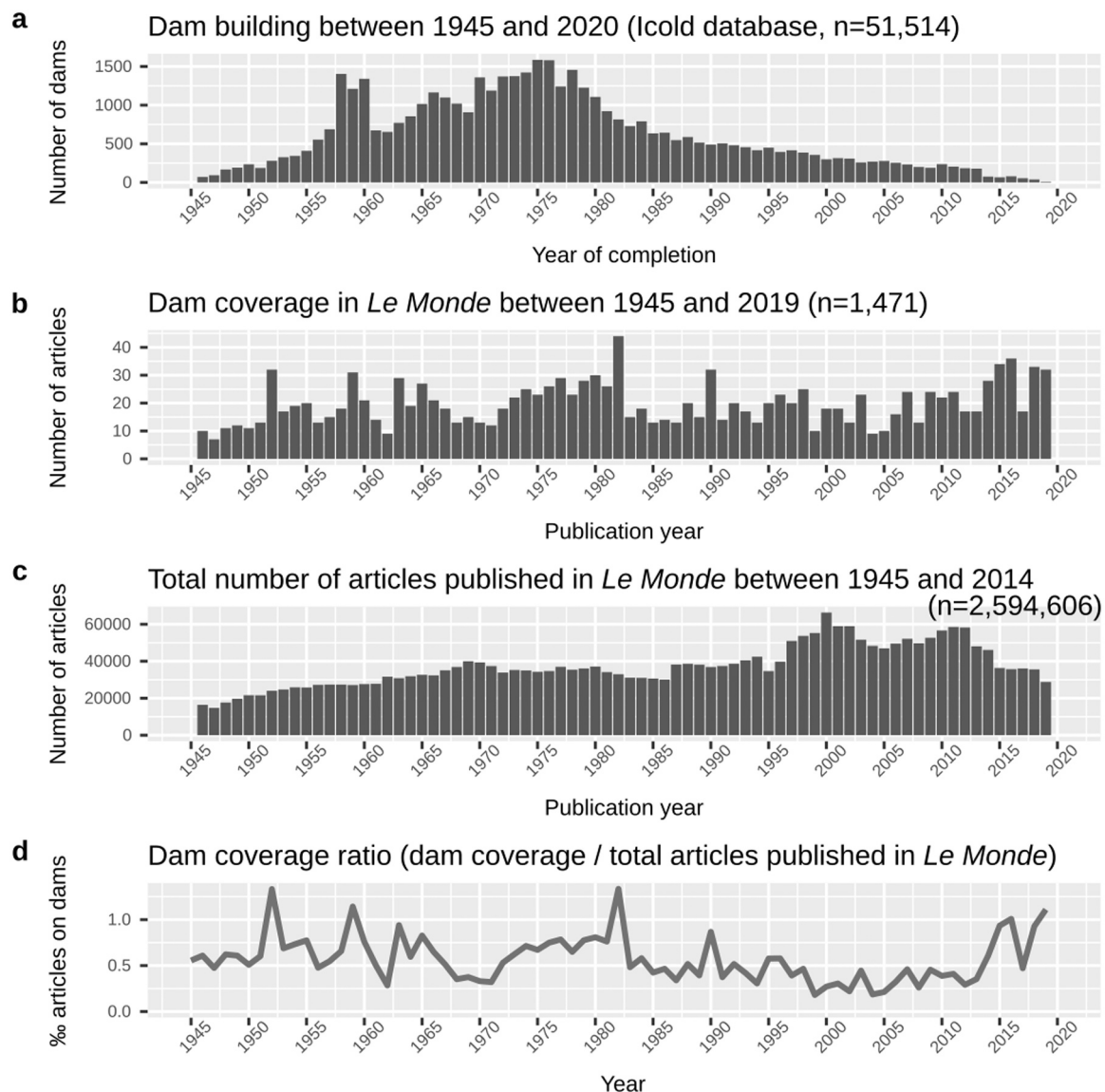


Fig. 1. Dam building in the world and dam coverage in *Le Monde* (1945–2019). a, Number of dams built between 1945 and 2020 according to the World Register of Dams database (n = 51514). b, Number of articles in the corpus on dams published between 1945 and 2019 in *Le Monde* (n = 1471). c, Total number of articles published in *Le Monde* between 1945 and 2019 (n = 2594606). d, Ratio between the number of articles on dams published in year in *Le Monde*, and the total number of articles published per year by the newspaper (per mille).

3.3. A discourse focused on the materiality of dams and on their economic and energy performances (1945–1960 s)

From 1945 to the beginning of the 1970 s, three lexical fields were over-represented in *Le Monde*'s articles on dams (Fig. 4). The journalists described in great detail technical aspects of dams, attaching particular importance to the size of the infrastructures.

Energy consumption and production were also a major theme of the articles in the 1940 s and 1950 s. This issue, coupled with economic questions along with industry, capital, finances, and development, were also frequently evoked. The focus on energy and economics is explainable by the fact that, during this period, whereas France was experiencing economic growth (the 'Trente Glorieuses' period, in connection with the Marshall Plan), the newspaper mainly described dams planned or under construction in France. The newspaper also focused on countries historically linked to France (colonies or ex-colonies, such as Morocco or the Ivory Coast), and dams financially supported by France or with involvement from French engineers (such as Aswan in Egypt, Fig. 2c, or Cahora Bassa in Mozambique).

A qualitative analysis of the newspaper articles showed that, between 1945 and the end of the 1960 s, dams were described as solutions to different types of crises such as drought, flood, water supply or energy shortage. The articles presented dams as tools for development and modernisation, most often on a national scale. Although most newspaper articles remained neutral (i.e., they did not explicitly support the dam projects), some articles demonstrated pride towards the infrastructures and engineering technicity. Regarding the Roselend scheme in the French Alps, a journalist asserted France's superiority over the United States or the Soviet Union: "None of the foreigners [who were visiting the dam and its power plant, La Bâthie] claimed to have something better at home. Not even a Soviet. Not even an American" (*Le Monde*, 10th August 1961). Dams were tightly linked with a discourse on national interests and on political and economic independence in the post-World War II and Cold War contexts. Some articles highlighted the beauty of the dams by comparing them to temples or cathedrals. In the newspaper articles, water was represented as raw material that does not have a cost, as a resource that could be entirely exploited for human activities by implementing "rational" projects. The Dordogne River (in

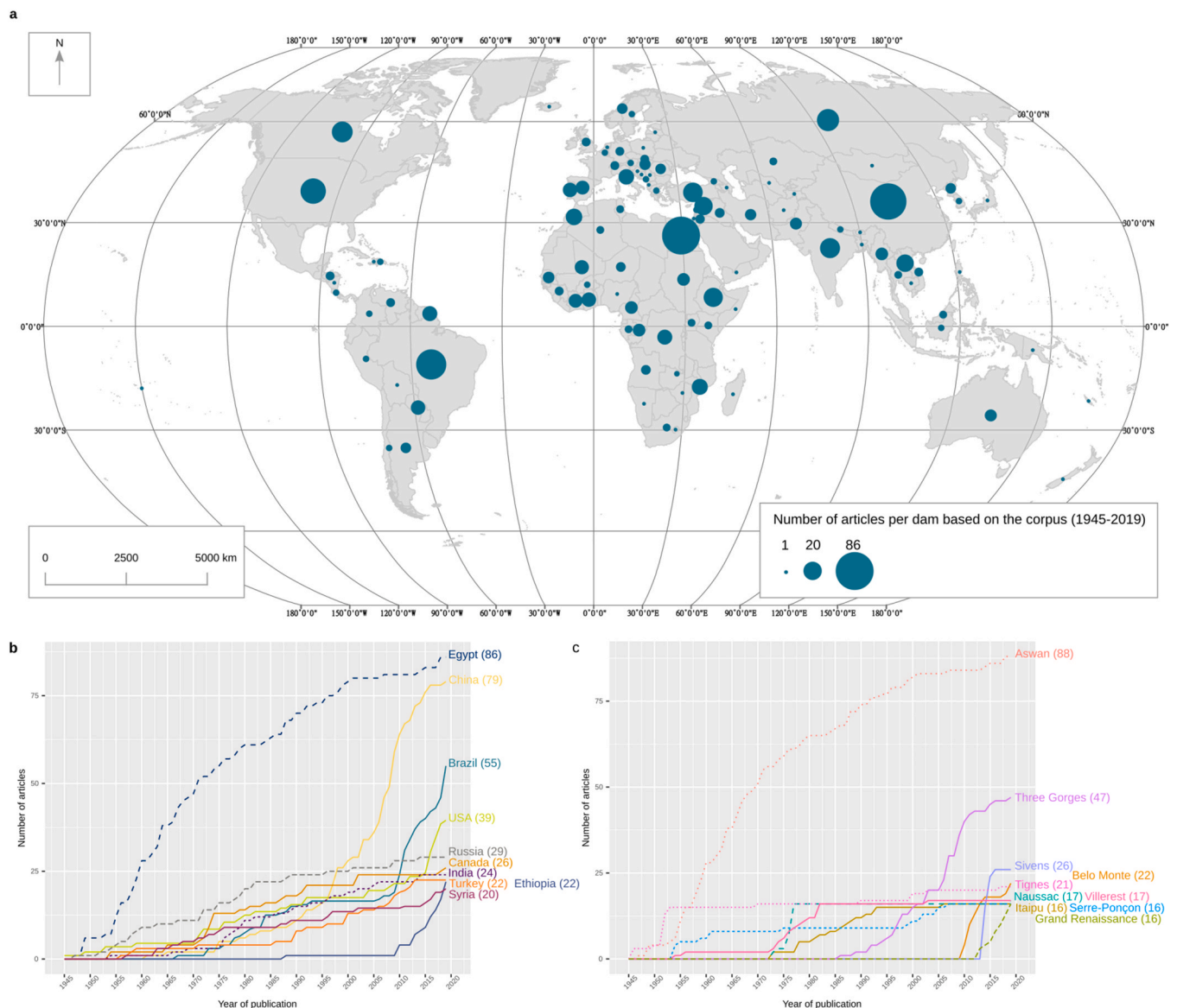


Fig. 2. Spatial characteristics of *Le Monde*'s coverage of dams (1945–2019). a, Articles on dams per country (excluding France). b, Cumulative frequency of the number of articles published on the ten main countries based on the corpus (excluding France). c, Cumulative frequency of the number of articles published on the ten main dams based on the corpus.

the southwest of France) was described as having been “rationally equipped” and as one of the “best examples of the complete usage of a river” (*Le Monde*, 1st July 1953). The newspaper articles rarely described the source of water and the environment in which water flows. Rather, journalists mentioned head and flow rate, “white coal” (“*houille blanche*”) when they described water, or “liquid stairways” (*Le Monde*, 25th May 1964).

Nevertheless, some articles mentioned debates, disputes and controversies before the 1970 s. Local negative consequences were evoked, notably those related to land loss (e.g., during the construction of the Tignes Dam in the Central French Alps), and regional oppositions between downstream and upstream interests (e.g., Serre-Ponçon Dam and the Durance valley in the French Southern Alps). Although some articles focused on the benefits of the Aswan High Dam (in Egypt), others underlined the geopolitical tensions linked to the project and the archaeological consequences of the inundation of Nubia even after the reconstruction of the Abu Simbel temple. The international campaign related to the dam, carefully followed and reported on by *Le Monde*, influenced French journalists to adopt a more critical perspective

regarding the benefits of dams. By the end of the 1960 s, a shift had taken place: while economics, energy production and the technical characteristics of dams played an increasingly smaller role in the discourses on dams, the articles began to question the assets of dams.

3.4. A discourse increasingly adding value to the socio-natural environment and landscape (1970–1980 s)

During the 1970 s and the 1980 s, as dam building reached its peak, dams were extremely topical (Fig. 1b and d). Nevertheless, these two decades did not present major specificities from a discursive point of view (Fig. 3). Although some themes grew during the 1970 s—such as landscape (Fig. 3, class 4)—and the 1980 s—such as politics and conflicts (class 3) or environmental protests (class 6)—they did not dominate the articles as much as energy or the technical aspects of dam building that dominated the articles in the 1950 s

While the journalists continued to focus on France or on the dams planned in France, the articles also turned towards North and South American dams (the most publicised having been Itaipu, Fig. 2c, on the

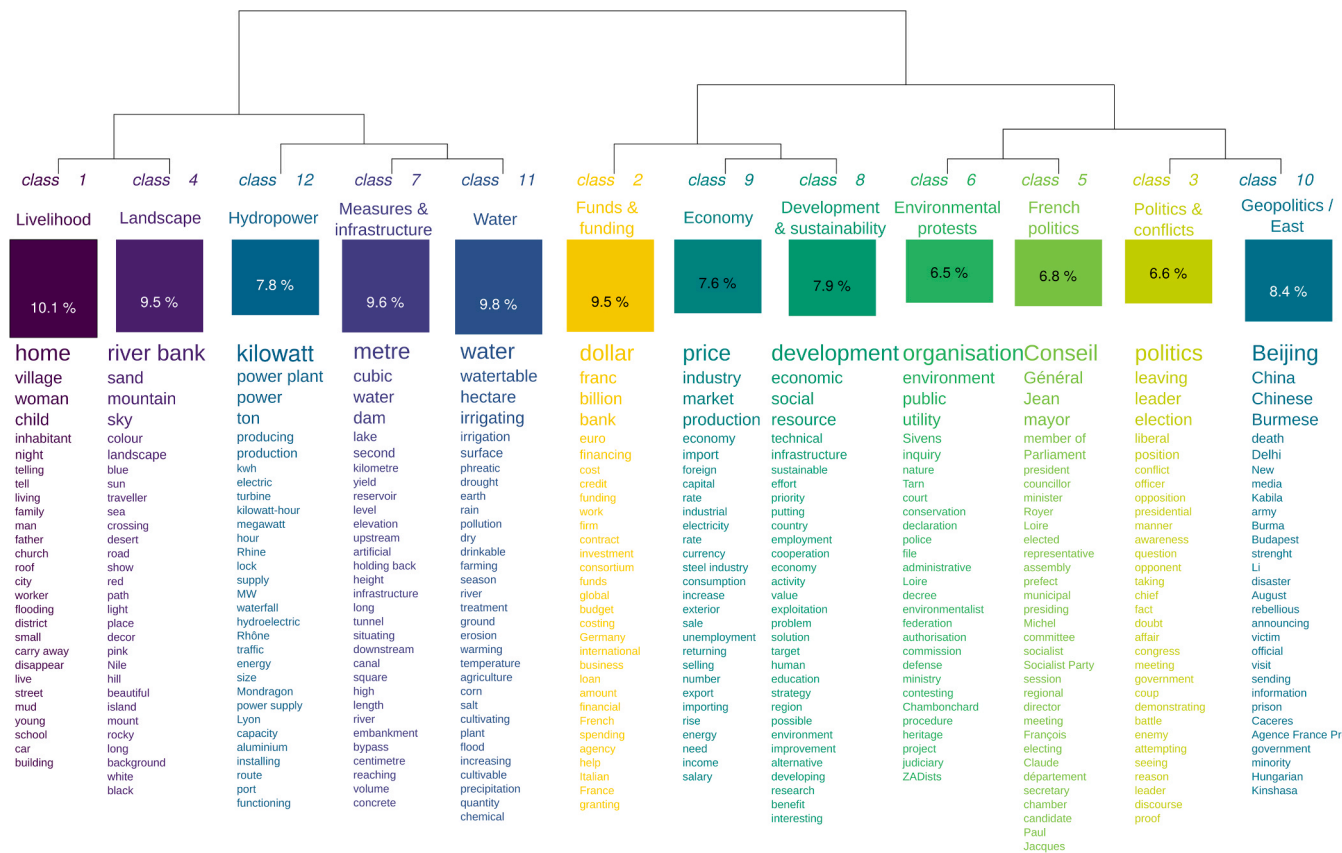


Fig. 3. The 12 lexical classes of *Le Monde's* articles on dams (1945–2019). The figure is the result of the hierarchical classification of the textual segments performed with Iramuteq. The authors added the keywords, established through a qualitative analysis, underneath the class numbers to facilitate reading the figure

border between Brazil and Paraguay) and towards some Asian dams. From the 1970 s, the negative consequences of dams appeared more and more although some articles continued to assert the benefits of dams in terms of development. The Oil Crises (which were evoked in three articles between 1977 and 1979) might have played a role in the latter case. The debates and controversies were no longer simply local or regional but were national and even international. The opposition to the Silent Valley Dam in India was described, for example, as part of a broad campaign to defend tropical environments and in particular tropical forests throughout the world. The inundation of farmland was increasingly cited (in particular in the Loire valley with Villerest or Naussac, Fig. 2c, in the centre of France but also in Haïti). By raising this topic, the journalists questioned both the type of nature desired by society and the economic model dominant in France and throughout the world. While the foreign dams built with French assistance continued to specifically attract the attention of journalists (for example, Itaipu, Fig. 2c), compared with articles of the 1950 s and 1960 s, the articles of the 1970 s and 1980 s were much more critical of French foreign aid. The building of dams on the Senegal River was described as leading to the “disappearance of subsistence agriculture in favour of the development of export crops” (*Le Monde*, 15th October 1983). Ongoing and past debates on American dams—the O’Shaughnessy in the Hetch Hetchy Valley or the Marble Canyon on the Colorado River—were evoked.

In some articles, dams became synonymous with environmental degradation and destruction. Since its inauguration in 1971, the Aswan High Dam has remained newsworthy (Fig. 2c) because of its negative impacts: the increase in soil salinity, river bank erosion, the disappearance of certain species such as sardines (*Sardina pilchardus*), and the regression of the Nile’s delta. In recent articles, Aswan has become a symbol of negative consequences of dams, in particular for arid countries. More attention was also paid to rivers in terms of pollution, yield,

temperature, and algae development. Subjects such as hydro-peaking, flushing flows, and discontinuity became newsworthy. For some journalists, once the dams were built, the nature of the river changed. The Verdon River (in the Southern French Alps) “has ceased to exist for a third of its distance” (*Le Monde*, 28th June 1982), for example, and the Tagus (in Central Spain) was “imprisoned by a series of dams” (*Le Monde*, 12th March 1971). During this period, the expressions “wild river” and “living river” appeared in journalistic vocabulary (Fig. 5a), which revealed the growing concern for pristine and rare environments. Starting in the 1980 s, some articles focused on or evoked plans for dams, which were cancelled because of environmental considerations in France but also in Germany, Australia, the United States and the Soviet Union.

According to *Le Monde*, dams became particularly controversial hydraulic infrastructures during the 1970 s and 1980 s, although no lexical fields particularly stood out in the corpus. During these two decades, while environmental concerns emerged, economic and social issues split apart as some dams were described as economically interesting but socially questionable.

3.5. From social and environmental impacts to controversies on sustainability (1990–2010 s)

3.5.1. A discourse on the impact of dams on water and physical environment and their interactions with society (1990 s–mid 2000 s)

During the 1990 s and the beginning of the 2000 s, the coverage of issues related to dams slightly decreased in *Le Monde* (Fig. 1d). Nonetheless, environmental protests became more topical during the 1990 s in relation to specific debates (for example, the Three Gorges project in China, Fig. 2c). The social and environmental impacts of dams continuously appeared—although the tone of the journalists remained neutral

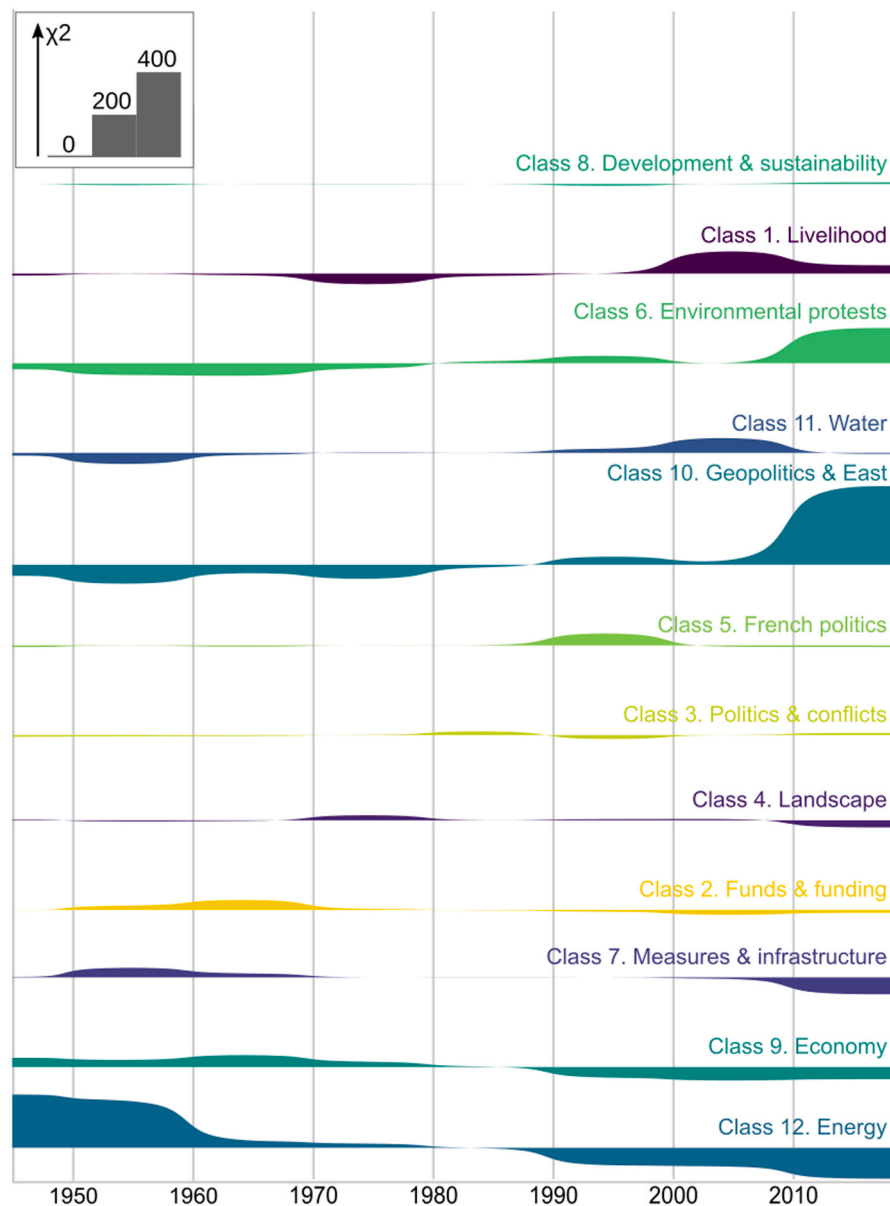


Fig. 4. Evolution of the 12 lexical classes between 1945 and 2019. The figure, made with RAW Graphs, shows the degree of association (χ^2) between the different classes and the decade of publication of the newspaper articles. The degree of association can be positive or negative (above or below the horizontal lines). The scale representing the degree of association is shown in the top-left corner of the figure.

in general. Impact on water (quality and quantity) also became more central (Fig. 4).

The introduction of such topics in the newspaper's accounts were linked to various events. Firstly, in 1992 the French government passed a water law and defined water as a national heritage. Secondly, at the end of the 1990 s, some members of the French government considered implementing a sustainable water development scheme for the Loire River basin. At the end of the 1990 s, such a program implied abandonment of dam projects, with an important example being the Chambonchard Dam (*Le Monde*, 19th February 1999). It represented a major turn for water development in France, as dam projects were cancelled due to environmental concerns and protests. Thirdly, the newspaper also highlighted newly discovered environmental impacts of dams, in particular the biological consequences of the release of methylmercury after the flooding of forests or boglands in Canada (*Le Monde*, 27th December 1991) or the release of greenhouse gas. The newspaper's columns debated the latter, when the main French operator *Électricité de France* (EDF) was obliged to temporarily shut down its newly

inaugurated dam and power plant of Petit Saut in French Guyana. The flooded tropical forest released so much methane that many fish suddenly died. Scientific studies demonstrating that the reservoir released important quantities of greenhouse gas that were quoted by the newspaper led journalists to conclude that "hydroelectric dams are not insignificant in terms of greenhouse effect" (*Le Monde*, 28th August 1995). The subject of greenhouse gas was introduced in some articles on dams since the early 1990 s (Fig. 5b) but only became topical at the end of the 1990 s and even more so after 2004.

3.5.2. When sustainability enters the discourse on dams (from the mid-2000 s)

Although international conferences and reports introduced the concept of sustainable development at the turn of the 1990 s (with the 1987 report *Our Common Future* and the 1992 Rio Earth Summit), based on *Le Monde*'s reporting, the sustainability of dams only became central in the discourses on dams after the mid-2000 s. The expression "sustainable development" appeared regularly since 2005 (Fig. 5b).

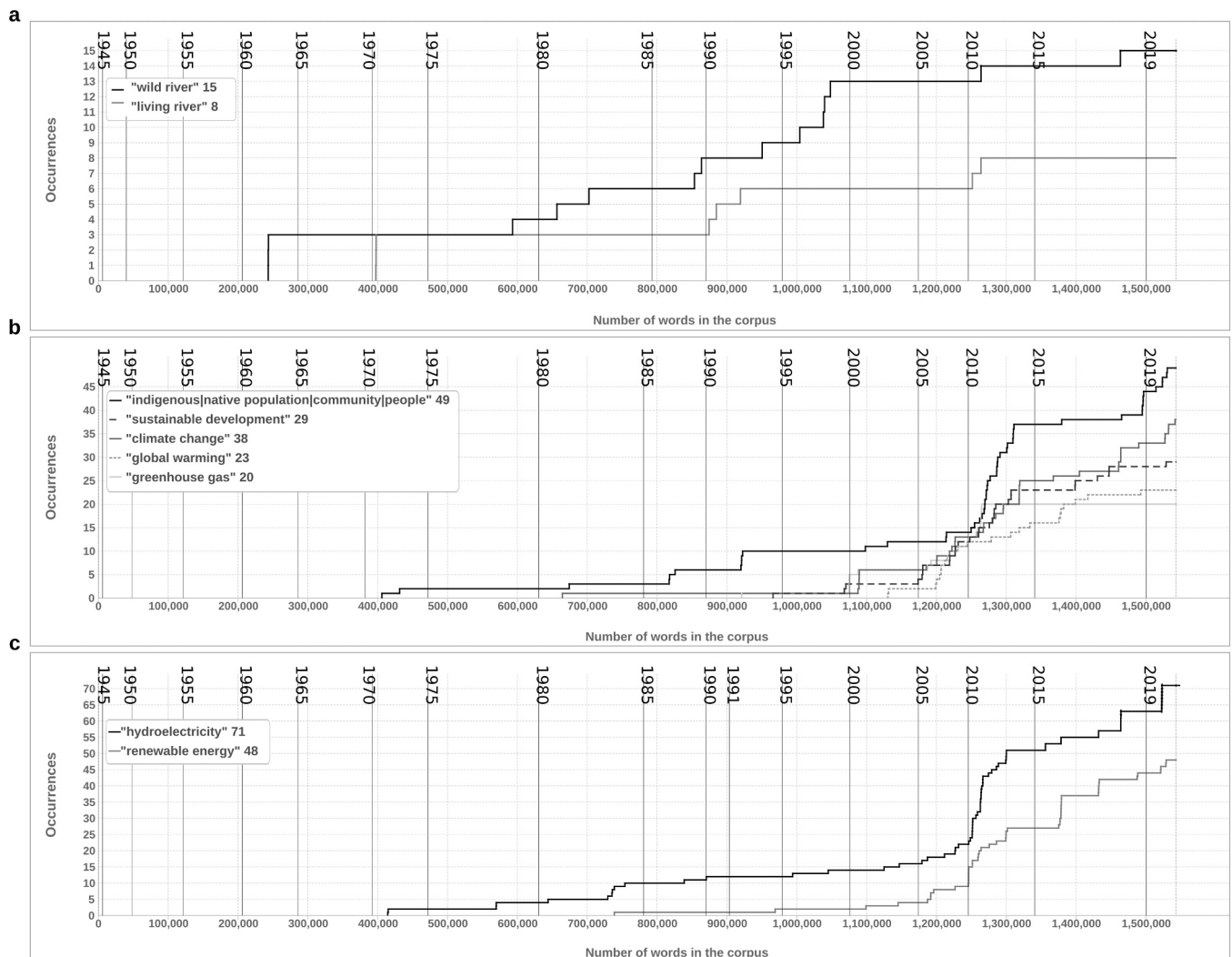


Fig. 5. Significant keywords and expressions and their evolution between 1945 and 2019. a, Cumulative frequencies of the expressions “wild river” and “living river”. b, Cumulative frequencies of the expressions “indigenous|native population|community|people”, “sustainable development”, “climate change”, “global warming”, “greenhouse gas”. c, Cumulative frequencies of the expressions “hydroelectricity” and “renewable energy”.

Similarly, the use of the expressions “climate change”, “global warming” and “sustainability” increased substantially after 2004 (Fig. 5b), possibly in relation to the 2001 Third Assessment Report of the Intergovernmental Panel on Climate Change. Economic development was tightly linked to environmental and social sustainability, as shown in the class 8 (Fig. 3), which gained momentum in the last decade (Fig. 4). Sustainability was shown as a paradigm for development and for water management that can be invoked to either defend or criticise dams. Livelihoods, living standards, social equity and justice and human rights were more and more reported on after 2000 (Fig. 4). *Le Monde* participated in giving indigenous communities an international audience (Fig. 5b), in particular in the cases of Southeastern Asian dams (such as Murum in Malaysia) or of South and North American dams (such as Belo Monte in Brazil, Fig. 2b or Agua Zarca in Honduras, or various Canadian projects), which may endanger these communities’ livelihoods, according to the newspaper.

The newspaper also explained, however, how different projects may contribute to sustainability. *Le Monde* reported that the Nam Theun 2 project, planned in Laos, was defended by the World Bank—although the World Bank had previously refused to finance some other dam projects—and presented by the international institution as an example of sustainable development (*Le Monde*, 14th September 2004). The construction of the multipurpose Kandadji Dam on the Niger River in the

South of Niger was also said to have raised no opposition “because the dam was conceived according to the standards of sustainability” (*Le Monde*, 10th May 2012). Instead, the story of an irrigation dam planned on the Acheloos River in Greece, was reported in the newspaper after the decision taken by the Greek Council of State (i.e., the Supreme Administrative Court) to prohibit the dam’s construction as the project contradicted the principles of sustainability recognised by the Greek constitution (*Le Monde*, 6th March 2014). In many recent articles focusing on China (which is the second most newsworthy country, Fig. 2a and 2b), the journalists argued that sustainability has entered the discourse of Chinese officials. This discourse focused on justifying the building of new dams when, in fact, the multiplication of dams and the accompanying growth and climate change “put pressure on hydrology” (*Le Monde*, 12th November 2008). The Three Gorges Dam, proposed by the Chinese government who “assured that such construction work is essential for the modernisation of a country where energy shortages are slowing development” (*Le Monde*, 16th December 1994), in fact “amplifies the consequences of global warming which has already contributed to diminishing the Yangzi River’s yield” (*Le Monde*, 30th December 2009). While irrigation represented a controversial topic, as demonstrated by the debates on the Sivens Dam project in Southwest France (Fig. 2c), “sustainable”, “development” and “renewable” are amongst words that co-occurred most with the word “hydroelectricity” in the

newspaper corpus. Although hydropower remained much less articulated as a theme connected to dam building than it was in the 1940 s and 1950 s, hydroelectricity became more topical in the newspaper also at the turn of the second millennium (Fig. 5c). The newspaper revealed the complexity of the debate. While indicating the possibility of greenhouse gas release related to certain dam-reservoirs, it also explained that after “the Fukushima accident, the questioning on nuclear power and the struggle against greenhouse gas emissions should speed up the scramble to large infrastructures” (*Le Monde*, 19th April 2011). The journalists covered explicitly the return to large infrastructures, especially in developing countries. While reporting on a meeting between the African Union and ICOLD, journalists explained that hydropower is presented as a clean “alternative to fossil energy resources” and the organisations’ “intentions are clear: large dams must become once again instruments for the development of nations” (*Le Monde*, 27th November 2008). The journalists also highlighted, however, that this return to large infrastructures can be a source of major political tensions, for example in the case of the Great Ethiopian Renaissance Dam, which the newspaper has very often reported on in recent years (Fig. 2c). By 2019, with the rise of an environmental discourse on economic, social and environmental sustainability, and the emergence of themes such as climate change, global warming and greenhouse gas emissions, the reporting on dams has therefore become more ambiguous and associated with uncertainty.

4. Discussion

Despite the fact that *Le Monde* does not specialise in environmental issues, the results of the analysis showed that the newspaper documented changes in discourses on hydraulic infrastructures such as dams. It provided insights on a continuing dilemma over the period and into the future: to dam or not to dam? Although dams have been controversial infrastructures as early as the 1940 s, it was mostly after the 1970 s that they were portrayed as disrupting social and environmental configurations, the daily living environments of the local inhabitants. From this point of view, the results showed a time gap between the scientific controversy on the impact of dams, which emerged during the 1960 s at conferences such as the Royal Geographical Society symposium on “Man-made lakes” (in 1965), and the media and political debate. The necessity to take into account the local population and conduct impact assessments, which was proposed by the scientific community at the beginning of the 1970 s (Scope, 1972), was not advanced in newspaper articles of *Le Monde* until later years of the same decade. The characterisation of dams and hydropower as ‘clean’ and ‘green’, which has been debated within the scientific community since the 1990 s (Rosenberg et al., 1995), only appeared in the media in the mid-2000 s. Moreover, while Allan (2003, p. 2) underlined that “the water sector in the North adopted the principles of sustainable development during a protracted discursive struggle from the late 1950 s to the mid-1970 s”, the issue of sustainability only progressively emerged in newspaper articles in the 1970 s and only became a prominent topic, conceptualised as such, in the past decade.

These results are similar to those of other studies on media coverage of environmental issues. In a study of the coverage of climate change in the mass-media of the United States, Boykoff and Boykoff (2007) explained that “Even though scientists had warned for years that emissions of carbon dioxide and other greenhouse gases would lead to changes in the Earth’s climate, this did not capture large-scale media attention in the US until 1988” (p. 1195). The time gap is also explainable by events not directly connected with dams, but which triggered a sudden interest in such infrastructure and its sustainability. In France, in the mid-2000 s, the government organised a multi-party debate on ecology and sustainable development (*Grenelle Environment*), whose aim was to elaborate a list of measures to implement. In 2002, the name of the Ministry for Environment (*Ministère de l’Environnement*), which had kept the same name since 1971, was

changed to ‘Ministry for Ecology and Sustainable Development’ (*Ministère de l’Écologie et du Développement Durable*). These political events could potentially explain the growing interest in the sustainability of dams in the mid-2000 s. As Boykoff and Boykoff (2007) underlined, increases in the media coverage of environmental topics are often attributable to “a combination of circumstances that [are] far from purely scientific in nature” (p. 1196).

From both a genealogical and critical perspective, results of this study showed that, until the 1970 s, *Le Monde* produced and conveyed a discourse highlighting human domination over nature. This discourse mostly promoted development and paid much attention to the infrastructures themselves. From the end of the Second World War to the 1970 s, the media’s discourse can essentially be described as ‘Promethean’ or ‘Modernist’ (Kaika, 2006), i.e., a discourse about taming and controlling a ‘savage’ nature (Boelens et al., 2019). With a strong focus on industrial development, the newspaper also highlighted the dependency of capitalist States and companies on the building of new dams and hydraulic infrastructure. In this perspective, dams appeared as ‘hydraulic fixes’—in other words, hydraulic projects branded by their supporters as tools for growth, social and economic development, but which in fact contribute essentially to the longevity of hydraulic companies and capitalist States (Swyngedouw, 2015). Evidenced in articles published after the 1970 s, the newspaper had apparently distanced itself from the Promethean discourse and adopted a more critical tone. The media began to pay more attention to human livelihoods but also to other nonhuman living beings. The evolution of the newspaper’s discourses illustrates how dams have become the ‘symbol of an exogenous development model that is imposed on vulnerable local societies’ (Barraud, 2011, p. 3).²

The genealogical approach utilised in this study also revealed how sustainability has entered the discourse on dams and shows a coexistence of different conceptions of sustainability. Although different stakeholders seemingly agree today that sustainability involves three constituent elements—ecology, economy and society—the newspaper articles showed changing prioritisations of these three elements (equitability, viability, bearability). The articles of the 1970 s and the 1980 s, for example, highlighted the opposition between stakeholders who favoured economy and who expressed few concerns regarding ecology—putting forward dams as equitable development levers—and stakeholders concerned with social changes related to dams, and finally an emerging group of stakeholders concerned with ecological issues. By the 2010 s, sustainability was apparently central to stakeholders on all sides—i.e., against or in favour of dams—and the environmental impact of energy infrastructures in particular was brandished by both dam proponents and dam opponents. For some stakeholders—in particular for some governments or hydraulic institutions—the articles showed that sustainability was more connected with social and economic aspects than with environmental ones. More generally, the tension between the different pillars of sustainability and the consequences of dams at different scales (e.g., local, national, and global) underlines the importance of deliberation in order to move towards concerted decision-making. It also reveals the extent to which the sustainability of dams, and notably the criteria we use to define viability (the opposition between river ecology conservation and carbon emission control) and equitability, has today become extremely controversial in the public domain.

5. Conclusions

In conclusion, analysis of media discourses held on dams since the mid-20th century revealed how different generations of debates on dams, water planning and more generally on development paradigms have emerged and evolved. Results of the genealogical study of the

² Translated from French by the authors.

newspaper *Le Monde* provided answers to the research questions posed in this paper as follows:

First, how have the discourses and debates on dams, and notably on the sustainability of dams, developed within the public domain?

Our analysis shows that between 1945 and 2019, different discourses have been developed on dams. Until the 1960 s, the dominant discourse focused on the materiality of dams and their economic and energy performances. Essentially Promethean, this discourse was occasionally opposed to a discourse presenting dams as controversial and having negative social and cultural impacts. During the 1970 s and the 1980 s, i. e., a decade after the beginning of the scientific controversy on dams, the discourse on dams increasingly added value to the socio-natural environment and landscape affected by dam projects; dams tended to be presented as economically interesting but socially and even environmentally questionable. After the 1990 s, the impacts of dams were more and more highlighted, in relation to society and to the physical environment. Finally, our results showed the extent to which the debate on the sustainability of dams has gained momentum during the past ten years.

However, the notion of sustainability was addressed in newspaper articles on dams in an ambivalent way. On one hand, negative social and environmental impacts of dams were listed to demonstrate that dams are incompatible with sustainability. On the other hand, the newspaper articles explained how in some cases hydropower projects could contribute to sustainable development.

Second, how can tracing a ‘genealogy’ of discourses on dams inform their sustainability into the future?

Analysing past and present discourses on dams can help inform future discussions on dams and their sustainability. Our results have shown that controversies about dams are not new in the public domain, and that the notion of sustainable development has to some extent reactivated the Promethean discourse in which dams are presented as solutions to a range of socio-environmental problems. Commonalities between past and present discourses can be found, even though the Promethean discourse is no longer dominant in the media we analysed.

The analysis of media discourses on dams also showed the complexity of the public debate regarding the knowledge of the social and ecological impacts of dams, of both short-term and long-term environmental alterations they may cause, and of the political choices to be made in the future. To gain more complete insights and continue informing discussions on dams and sustainability, future work can extend to other media sources, as archives are becoming more and more digitised. Additional sources may reveal different trends in the evolution of discourses on dams and the integration of sustainability within these discourses. Other avenues may include exploration of the sustainability of dams as producing ‘green energy’, as well as the study of other sources, notably the advertisements (e.g., leaflets, posters, etc.) produced by hydropower companies. Results from this study further suggest a need for a stronger dialogue between the scientific and public domains. Knowledge transfer and exchange would be beneficial on topics including the meaning of ‘renewable energy’ and ‘green energy,’ and alternative modes of governance regarding dams.

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CRediT authorship contribution statement

S.F. designed the study with input from H.P. and Y.F.L.L. S.F. built and analysed the corpus. S.F. wrote the article with contributions from H.P. and Y.F.L.L.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Conflict of interest

The authors declare no competing interests.

References

- Adger, W.N., Benjaminsen, T.A., Brown, K., Svarstad, H., 2001. Advancing a political ecology of global environmental discourses. *Dev. Change* 32 (4), 681–715. <https://doi.org/10.1111/1467-7660.00222>.
- Ahlers, R., Budds, J., Joshi, D., Merme, V., Zwartveen, M., 2015. Framing hydropower as green energy: assessing drivers, risks and tensions in the Eastern Himalayas. *Earth Syst. Dyn.* 6 (1), 195–204. <https://doi.org/10.5194/esd-6-195-2015>.
- Allan, T., 2003. IWRM/IWRAM: A New Sanctioned Discourse. SOAS Water Issues Study Group, Occasional Paper 50. SOAS Water Issues Study Group, pp. 1–27. <https://iwrw.files.wordpress.com/2014/12/iwrw-a-new-sanctioned-discourse.pdf>.
- Baghel, R., Nüsser, M., 2010. Discussing large dams in Asia after the World Commission on Dams: Is a political ecology approach the way forward? *Water Alternatives* 3 (2), 231–248. <https://www.water-alternatives.org/index.php/volume3/v3issue2/91-a3-2-14/file>.
- Barraud, R., 2011. Rivières du futur, wild rivers? *Vertigo-La revue électronique en sciences de l’environnement* 10. <https://doi.org/10.4000/vertigo.11411>.
- Beaudouin, V., 2016. Statistical analysis of textual data: Benzécri and the French school of data analysis. *Glottometrics* 33, 56–72. <https://hal.telecom-paris.fr/hal-02191472/document>.
- Best, J., 2019. Anthropogenic stresses on the world’s big rivers. *Nat. Geosci.* 12, 7–21. <https://doi.org/10.1038/s41561-018-0262-x>.
- Boelens, R., Hoogesteger, J., Swyngedouw, E., Vos, J., Wester, P., 2016. Hydrosocial territories: a political ecology perspective. *Water Int.* 41 (1), 1–14. <https://doi.org/10.1080/02508060.2016.1134898>.
- Boelens, R., Shah, E., Bruins, B., 2019. Contested knowledges: large dams and mega-hydraulic development. *Water* 11 (3), 416. <https://doi.org/10.3390/w11030416>.
- Boyer, A.-L., Vaudor, L., Le Lay, Y.-F., Marty, P., 2021. Building consensus? The production of a water conservation discourse through twitter: the water use it wisely campaign in Arizona. *Environ. Commun.* 15 (3), 285–300. <https://doi.org/10.1080/17524032.2020.1821743>.
- Boykoff, M.T., Boykoff, J.M., 2007. Climate change and journalistic norms: a case-study of US mass-media coverage. *Geoforum, Theme Issue: Geogr. Generosity* 38 (6), 1190–1204. <https://doi.org/10.1016/j.geoforum.2007.01.008>.
- Brossard, D., Shanahan, J., McComas, K., 2004. Are issue-cycles culturally constructed? A comparison of French and American coverage of global climate change. *Mass Commun. Soc.* 7 (3), 359–377. https://doi.org/10.1207/s15327825mcs0703_6.
- Brundtland, G.H., 1987. Report of the World Commission on environment and development: our common future. U. Nations.
- Burgess, J., 1990. The Production and Consumption of Environmental Meanings in the Mass Media: A Research Agenda for the 1990s. *Trans. Inst. Br. Geogr.* 15 (2), 139–161. <https://doi.org/10.2307/622861>.
- Chin, A., Fu, R., Harbor, J., Taylor, M.P., Vanacker, V., 2013. Anthropocene: human interactions with earth systems. *Anthropocene* 1, 1–2. <https://doi.org/10.1016/j.ancene.2013.10.001>.
- Comby, E., Le Lay, Y.-F., Piégay, H., 2019. Power and changing riverscapes: the socioecological fix and newspaper discourse concerning the Rhône River (France) since 1945. *Ann. Am. Assoc. Geogr.* 109 (6), 1671–1690. <https://doi.org/10.1080/24694452.2019.1580134>.
- Conway, D., Dalin, C., Landman, W.A., Osborn, T.J., 2017. Hydropower plans in eastern and southern Africa increase risk of concurrent climate-related electricity supply disruption. *Nat. Energy* 2, 946–953. <https://doi.org/10.1038/s41560-017-0037-4>.
- Cottet, M., Piola, F., Le Lay, Y.-F., Rouifed, S., Rivière-Honegger, A., 2015. How environmental managers perceive and approach the issue of invasive species: the case of Japanese knotweed s.l. (Rhône River, France). *Biol. Invasions* 17, 3433–3453. <https://doi.org/10.1007/s10530-015-0969-1>.

- Crow-Miller, B., Webber, M., Molle, F., 2017. The (re) turn to infrastructure for water management? *Water Altern.* 10 (2), 195–207. <https://www.water-alternatives.org/index.php/alldoc/articles/vol10/v10issue2/351-a10-2-1/file>.
- Crutzen, P., 2002. Geology of mankind. *Nature* 415, 23. <https://doi.org/10.1038/415023a>.
- de Loë, R.C., 1999. Dam the news: newspapers and the Oldman River Dam project in Alberta. *J. Environ. Manag.* 55 (4), 219–237.
- Di Baldassarre, G., Mazzoleni, M., Rusca, M., 2021. The legacy of large dams in the United States. *Ambio* 50, 1798–1808. <https://doi.org/10.1007/s13280-021-01533-x>.
- Di Baldassarre, G., Wanders, N., AghaKouchak, A., Kuil, L., Rangelcroft, S., Veldkamp, T.I. E., Garcia, M., van Oel, P.R., Breinl, K., Van Loon, A.F., 2018. Water shortages worsened by reservoir effects. *Nat. Sustain* 1, 617–622. <https://doi.org/10.1038/s41893-018-0159-0>.
- Downs, A., 2016. Up and down with ecology: The “issue attention cycle.” In: Prottess, D., McCombs, M.E. (Eds.), *Agenda Setting: Readings on Media, Public Opinion, and Policymaking*. Routledge, pp. 38–50.
- Dryzek, J.S., 2012. *The Politics of the Earth: Environmental Discourses*, Third edition. ed., Oxford University Press, Oxford, New York.
- Duarte-Abadía, B., Boelens, R., Roa-Avedaño, T., 2015. Hydropower, encroachment and the re-patterning of hydrosocial territory: the case of Hidrosogamoso in Colombia. *Hum. Organ.* 74 (3), 243–254. <https://doi.org/10.17730/0018-7259-74.3.243>.
- Fletcher, R., 2010. When environmental issues collide: climate change and the shifting political ecology of hydroelectric power. *Peace Confl. Rev.* 5 (1), 14–30. ISSN: 1659-3995.
- Foucault, M., 1971. L'ordre du discours: leçon inaugurale au Collège de France prononcée le 2. décembre 1970. Gallimard, Paris.
- Foxwell-Norton, K., Lester, L., 2017. Saving the Great Barrier Reef from disaster, media then and now. *Media, Cult. Soc.* 39 (4), 568–581.
- Fung, Z., Pomun, T., Charles, K.J., Kirchherr, J., 2019. Mapping the social impacts of small dams: The case of Thailand's Ing River basin. *Ambio* 48, 180–191. <https://doi.org/10.1007/s13280-018-1062-7>.
- Gleick, P.H., 2000. A look at twenty-first century water resources development. *Water Int.* 25 (1), 127–138. <https://doi.org/10.1080/02508060008686804>.
- Graf, W.L., 1999. Dam nation: a geographic census of American dams and their large-scale hydrologic impacts. *Water Resour. Res.* 35 (4), 1305–1311.
- Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., Babu, S., Borrelli, P., Cheng, L., Crochetiere, H., Ehalt Macedo, H., Filgueiras, R., Goichot, M., Higgins, J., Hogan, Z., Lip, B., McClain, M.E., Meng, J., Mulligan, M., Nilsson, C., Olden, J.D., Opperman, J.J., Petry, P., Reidy Liermann, C., Sáenz, L., Salinas-Rodríguez, S., Schelle, P., Schmitt, R.J.P., Snider, J., Tan, F., Tockner, K., Valdujo, P. H., van Soesbergen, A., Zarfl, C., 2019. Mapping the world's free-flowing rivers. *Nature* 569, 215–221. <https://doi.org/10.1038/s41586-019-1111-9>.
- Gross, M., 2016. A global megadam mania. *Curr. Biol.* 26 (17), R779–R782. <https://doi.org/10.1016/j.cub.2016.08.050>.
- Hajer, M.A., 1995. *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford University Press, Oxford. <https://doi.org/10.1093/019829333X.001.0001>.
- Hansen, A., 2015. News coverage of the environment: a longitudinal perspective, in: Hansen, A., Cox, R. (Eds.), *The Routledge Handbook of Environment and Communication*. pp. 209–220.
- Heiden, S., Magué, J.-P., Pincemin, B., TXM: Une plateforme logicielle open-source pour la textométrie-conception et développement. https://halshs.archives-ouvertes.fr/halshs-00549779/file/Heiden_al_jadt2010.pdf.
- Hommes, L., Boelens, R., Maat, H., 2016. Contested hydrosocial territories and disputed water governance: struggles and competing claims over the Ilisu Dam development in southeastern Turkey. *Geoforum* 71, 9–20.
- ICOLD, 2018. *World Register of Dams*. ICOLD: International Commission on Large Dams, Paris. (https://www.icold-cigb.org/GB/world_register/world_register_of_dams.asp).
- Lester, L., 2010. Media and Environment: Conflict, Politics and the News. Polity.
- Kaika, M., 2006. Dams as Symbols of Modernization: The Urbanization of Nature Between Geographical Imagination and Materiality. *Annals of the Association of American Geographers* 96 (2), 276–301. <https://doi.org/10.1111/j.1467-8306.2006.00478.x>.
- Magilligan, F.J., Graber, B.E., Nislow, K.H., Chipman, J.W., Sneddon, C.S., Fox, C.A., 2016. River restoration by dam removal: Enhancing connectivity at watershed scales. *Elem.: Sci. Anthr.* 4 <https://doi.org/10.12952/journal.elementa.000108>.
- Mauri, M., Elli, T., Caviglia, G., Ubaldi, G., Azzi, M., 2017. RAWGraphs: A Visualisation Platform to Create Open Outputs. In: *Proceedings of the 12th Biannual Conference on Italian SIGCHI Chapter, CHIItaly '17*, 28. ACM, New York, NY, USA, pp. 1–5.
- McCully, P., 2001. *Silenced Rivers: The Ecology and Politics of Large Dams, Enlarged&Updated edition.*, Zed Books., London; New York.
- Nilsson, C., Reidy, C., Dynesius, M., Revenga, C., 2005. Fragmentation and flow regulation of the world's large river systems. *Science* 308 (5720), 405–408. <https://doi.org/10.1126/science.1107887>.
- Nüsser, M., Baghel, R., 2017. *The Emergence of Technological Hydroscales in the Anthropocene: Socio-hydrology and Development Paradigms of Large Dams*. In: Warf, B. (Ed.), *Handbook on geographies of technology*. Edward Elgar Publishing, pp. 287–301.
- Palmer, M.A., Reidy Liermann, C.A., Nilsson, C., Flörke, M., Alcamo, J., Lake, P.S., Bond, N., 2008. Climate change and the world's river basins: anticipating management options. *Front. Ecol. Environ.* 6 (2), 81–89. <https://doi.org/10.1890/060148>.
- Pezzullo, P.C., Cox, R., 2017. *Environmental Communication and the Public Sphere*, 5th edition. SAGE Publications, Inc, Los Angeles, California.
- Poff, L.N., Allan, J.D., Bain, M.B., Karr, J.R., Prestegard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C., 1997. The natural flow regime: a paradigm for river conservation and restoration. *Bioscience* 47 (11), 769–784. <https://doi.org/10.2307/1313099>.
- Power, M., Dietrich, W.E., Finlay, J.C., 1996. Dams and downstream aquatic biodiversity: potential food web consequences of hydrologic and geomorphic change. *Environ. Manag.* 20 (6), 887–895. <https://doi.org/10.1007/BF01205969>.
- Ratinaud, P., Déjean, S., 2009. IRaMuTeQ: implémentation de la méthode ALCESTE d'analyse de texte dans un logiciel libre. *Modélisation Appliquée Aux. Sci. Hum. Et. Soc. MASHS* 8–9.
- Reinert, M., 1990. Alceste une méthodologie d'analyse des données textuelles et une application: Aurelia De Gerard De Nerval. *Bull. De. méthodologie Sociol.* 26 (1), 24–54. <https://doi.org/10.1177/075910639002600103>.
- Reinert, M., 1983. Une méthode de classification descendante hiérarchique: application à l'analyse lexicale par contexte. *Cah. de l'Analyse des Données* 8 (2), 187–198. http://www.numdam.org/article/CAD_1983__8_2_187_0.pdf.
- Roe, A., 2012. *Riverine Environments*. In: McNeill, J.R., Stewart Muldin, E. (Eds.), *A Companion to Global Environmental History*. John Wiley & Sons, Ltd, pp. 297–318.
- Rollet, A.J., Piégay, H., Dufour, S., Bornette, G., Persat, H., 2014. Assessment of consequences of sediment deficit on a gravel river bed downstream of dams in restoration perspectives: application of a multicriteria, hierarchical and spatially explicit diagnosis. *River Res. Appl.* 30 (8), 939–953. <https://doi.org/10.1002/rra.2689>.
- Rosenberg, D., Bodaly, R.A., Usher, P.J., 1995. Environmental and social impacts of large scale hydroelectric development: who is listening? *Glob. Environ. Change* 5 (2), 127–148. [https://doi.org/10.1016/0959-3780\(95\)00018-J](https://doi.org/10.1016/0959-3780(95)00018-J).
- Scope, 1972. Man-made lakes as modified ecosystems. International Council of Scientific Unions, Paris.
- Skalak, K.J., Benthem, A.J., Schenk, E.R., Hupp, C.R., Galloway, J.M., Nustad, R.A., Wiche, G.J., 2013. Large dams and alluvial rivers in the Anthropocene: the impacts of the Garrison and Oahe Dams on the Upper Missouri River. *Anthropocene* 2, 51–64. <https://doi.org/10.1016/j.ancene.2013.10.002>.
- Swyngedouw, E., 2015. *Liquid Power - Contested Hydro-Modernities in Twentieth-Century Spain*. MIT Press, Cambridge, Massachusetts.
- Warner, J.F., Hoogesteger, J., Hidalgo, J.P., 2017. Old wine in new bottles: the adaptive capacity of the hydraulic mission in Ecuador. *Water Altern.* 10 (2), 322–340. <http://www.water-alternatives.org/index.php/alldoc/articles/vol10/v10issue2/358-a10-2-8/file>.
- Wei, J., Wei, Y., Western, A., 2017. Evolution of the societal value of water resources for economic development versus environmental sustainability in Australia from 1843 to 2011. *Glob. Environ. Change* 42, 82–92. <https://doi.org/10.1016/j.gloenvcha.2016.12.005>.
- Wei, J., Wei, Y., Western, A., Skinner, D., Lyle, C., 2015. Evolution of newspaper coverage of water issues in Australia during 1843–2011. *Ambio* 44, 319–331. <https://doi.org/10.1007/s13280-014-0571-2>.
- Williams, M., Zalasiewicz, J., Davies, N., Mazzini, I., Goiran, J.-P., Kane, S., 2014. Humans as the third evolutionary stage of biosphere engineering of rivers. *Anthropocene* 7, 57–63. <https://doi.org/10.1016/j.ancene.2015.03.003>.
- World Commission on Dams, 2000. *Dams and development: a new framework for decision-making: The report of the World Commission on Dams*. Earthscan.,
- Zarfl, C., Lumsdon, A.E., Berlekamp, J., Tydecks, L., Tockner, K., 2015. A global boom in hydropower dam construction. *Aquat. Sci.* 77, 161–170. <https://doi.org/10.1007/s00027-014-0377-0>.