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RESEARCH



## Disentangling the complexity of socio-cultural values of temporary rivers

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### ABSTRACT

In the last decade, an awareness towards temporary rivers has increased globally in response to drying climates and growing human demand for water. However, social perceptions of temporary rivers have rarely been incorporated in their science and management. In this study, we advance an understanding of the socio-cultural values of temporary rivers principally in a European context. We used an ecosystem services-based approach for a participatory and deliberative exercise with 16 researchers and managers. Our results point out to two important aspects of socio-cultural values in temporary rivers. First, cultural ecosystem services have high socio-cultural values and usually represent the interests of the less influential stakeholders in related conflicts. And second, the temporal and geographical variability of these types of rivers is key to understand their socio-cultural values. As an example, the low provision of freshwater in a long non-flowing phase is one of the reasons for its high value. The results above point to future research needs that deserve more attention like the study of tradeoffs and synergies of ecosystem services and interdisciplinary research and management. We finally acknowledge the need to conduct case study research to account for geographical variation and to include the multiple views of different stakeholder groups.

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## 1. Introduction

Temporary rivers represent between 34% and 69% of the world's inland waters below 60° latitude, and are gaining widespread attention (Acuña et al. 2014). Temporary rivers, also referred to as intermittent rivers, are defined as watercourses that cease to maintain surface flow at some points in space and time along their course (Acuña et al. 2014). They are shaped by alternating wet and dry periods (i.e. flowing and non-flowing phases) over annual and inter-annual cycles, so temporary rivers are one of the most dynamic freshwater ecosystems hydrologically (Arthington et al. 2014). Research on these ecosystems has been more abundant in arid, semi-arid and Mediterranean-climate regions of the world, where sizable rivers may be temporary (Thorpe and Covich 2015). However, research interests have extended into more humid and cold regions, where rivers can be interrupted not only in hot dry summers but by periods of freezing too (Leigh et al.

2016). The alternation of flowing and non-flowing phases can promote higher biodiversity, than their permanently flowing counter-parts, and supports a range of ecosystem processes providing valuable ecosystem services that are key for maintaining the health and well-being of local communities (Acuña et al. 2014; Koundouri et al. 2017; Datry et al. 2018; Stubbington et al. 2020).

In the last decade, the awareness towards ecosystems associated with temporary rivers has become more prevalent in response to increasing aridity and growing human demand for water (Datry et al. 2018; Leigh et al. 2019). Unfortunately, they have been largely ignored by scientists working in aquatic or terrestrial ecology, probably because they are perceived to be outside the domain of both respective disciplines (Steward et al. 2012; Leigh et al. 2016). Recently, various research networks have emerged to increase the visibility and importance

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of these ecosystems, such as the 1000 intermittent rivers project or the Science and Management of Intermittent Rivers and Ephemeral Streams COST Action (2018). These science-led projects aim to gather data and conduct joint experiments, to consolidate and expand the current understanding of temporary rivers, and to develop evidence-based sustainable management of such rivers (Jorda-Capdevila et al. 2020). However, temporary river ecosystems continue being degraded at alarming rates due to anthropogenic pressures such as hydro-morphological alteration, disposal of wastewater and other disturbances, which are likely to increase under climate change (Acuña et al. 2017). Among other causes, the lack of recognition, understanding, and proper management of temporary rivers leads to serious degradation of these ecosystems accompanied by negative impacts to the societies that depend upon them (Acuña et al. 2014). In addition, terrestrial attributes related to the non-permanency of flow have promoted the underestimation of their ecological and socio-cultural values, being regarded as secondary ecosystems relative to permanent watercourses (Acuña et al. 2017).

The management of temporary rivers presents many new challenges, not least how to reconcile ecological and societal goals, given their value and desirable ecological services to society (Arthington et al. 2014). Although temporary rivers are often linked with negative connotations, dry riverbeds are an integral part of some river landscapes and are associated with a range of important societal and ecological values (Steward et al. 2012). It is often argued that local people show less awareness and appreciation towards these ecosystems compared to permanent rivers, which flow all year round (Armstrong et al. 2012; Leigh et al. 2019, Rodríguez-Lozano et al. 2020). For instance, Armstrong et al. (2012) found in a study in the US that flow permanence positively influences the attitudes of landowners towards the rivers on their properties, and their concern over water quality. However, Gibbs (2010) argues that diverse values are influenced by diverse backgrounds and livelihoods. Nevertheless, the generalized low awareness towards values of temporary rivers has not encouraged scientists to incorporate social science perspectives in their research (Steward et al. 2012).

Over the past decades, the ecosystem service approach (i.e. nature's contributions to human well-being) has gained importance as a way to communicate societal dependence on ecological life support systems integrating both the natural and social science perspectives (Bastian et al.

2012). One of the cornerstones of the ecosystem service-based approaches is the consideration of socio-cultural values as a key part of sustainable management of ecosystems. Recent academic literature has acknowledged that gaining clarity about socio-cultural values is essential for decision-makers to better manage conflicts over natural resources, to assess the social-ecological impacts of policy, and to develop effective sustainable management strategies (Kenter et al. 2015). A better understanding of the socio-cultural values of temporary rivers is further important because rivers' stakeholders (e.g. indigenous peoples and local communities, other local users, managers, scientists) tend to have contrasting perceptions of the different ecosystem services provided by them (Brummer et al. 2017). This can potentially create conflicts and hinder the conservation and management of temporary rivers.

The socio-cultural valuation of ecosystem services covers an umbrella of approaches that aim to analyze human preferences towards ecosystem services in non-monetary units. Under this umbrella, different methodologies uncover individual and collective values and perceptions of ecosystem services (Castro et al. 2013; Iniesta-Arandia et al. 2014). This type of valuation is increasingly important given that acknowledges the interactions of people and ecosystems beyond extractive or utilitarian uses (e.g. feelings of place attachment, aesthetic experiences or other experiences categorized under the cultural ecosystem services label) (Hanacek and Rodríguez-Labajos 2018). Socio-cultural values associated with temporary rivers have barely been studied (but see Gibbs 2010; Leigh et al. 2019), and socio-cultural approaches have not been employed either.

The overall aim of this study is to advance the agenda of social perceptions of temporary rivers by using an ecosystem services-based approach in order to inform their science and management. To achieve this, we used a deliberative and participatory approach and, through the knowledge of researchers and managers, we: (1) explore the research needs regarding social perceptions of temporary rivers, (2) scrutinize the socio-cultural values of ecosystem services provided by temporary rivers using a non-monetary approach, and (3) analyze how inter-stakeholders conflicts emerge from different socio-cultural values of ecosystem services in two different case studies. We finally discuss how temporary rivers research and management would benefit from the incorporation of social perceptions and conclude with some insights for further research and management.

## 2. Methods: a workshop for exploring socio-cultural values of temporary rivers

In 2019, sixteen participants from different backgrounds and disciplines met for a two-day workshop within the context of the SMIRES COST Action (Jorda-Capdevila et al. 2020). The goal of the workshop was to discuss the state of research on social perceptions of temporary rivers and advance it through the identification of current needs and the performance of a socio-cultural valuation and conflict analysis. Participants were selected from the WG2 work package of the SMIRES COST Action, which worked on ‘flow alterations, ecosystem services and management of IRES’, so researchers and managers were already aware of the ecosystem services concept when the workshop took place. Among 79 WG2 members, we selected the participants according to four criteria, i.e. country, working area, experience and gender, besides their interest and suitability to participate. We selected a group of participants from different climate zones, ranging from the Mediterranean to the Northern Europe representing thirteen different countries. Different perceptions are likely to exist among geographical areas – more likely positive in Mediterranean and arid climate zones where temporary rivers abound, and possibly more negative where they are less common, such as in oceanic-temperate climate areas – according to Köppen classification of climates (Steward et al. 2012; Stubbington et al. 2018a). Participants represented four different backgrounds: river managers, natural scientists, social scientists, and interdisciplinary scientists. Their expertise as well as some previous interest and experience in applying social sciences were also selection criteria. In addition, other criteria such as gender and experience as junior or senior researchers were taken into account (Table 1).

We organized the workshop based on three parts that included different participation dynamics (see Figure 1 and the workshop agenda in Appendix A). In the first part, participants gave a set of place-based research presentations to get a deeper understanding of the state of the art of the research about the social perceptions of temporary rivers. Presentations covered studies with a biophysical perspective (De Girolamo et al. 2015, 2017; Kaletová et al. 2019), socio-economic assessments of rivers (Logar et al.

2019), novel methodologies to assess ecosystem service provision (Keele et al. 2019), conceptual approaches to social perceptions, and a few studies on social perception towards temporary rivers (Cottet et al. 2019). Then, we collectively discussed the research gaps about social perceptions and temporary rivers, and grouped them into different categories, reaching a consensus.

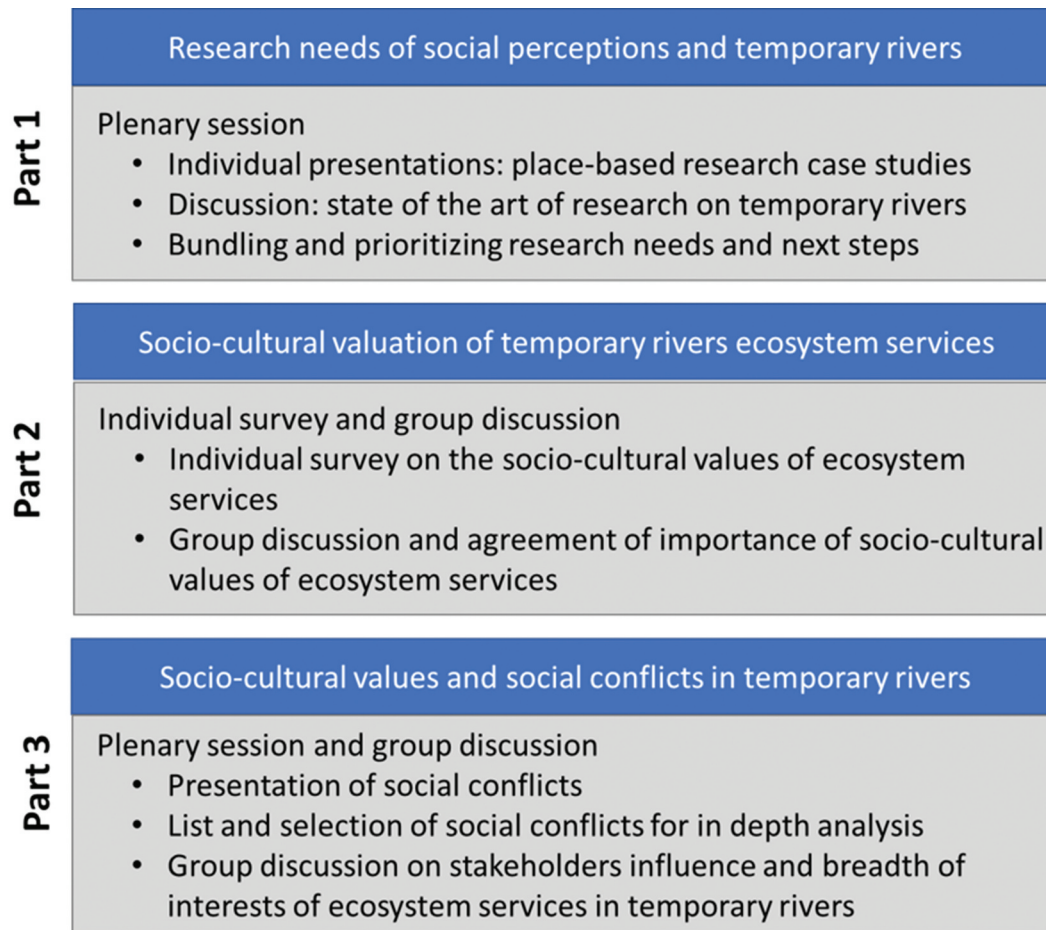
In the second part of the workshop, individual participants filled out a socio-cultural valuations exercise of ecosystem services in temporary rivers (see Figure 1 and Appendix B). Participants had to focus on a geographical area which they were familiar with, and then indicate the level of importance for well-being as perceived by the local public of the corresponding area. We use the level of importance of the ecosystem services provided as an indicator for socio-cultural values. We used a Likert scale ranging from 1 (not important at all) to 5 (very important) of 18 ecosystem services provided by temporary rivers, considering both flowing and non-flowing phases. The ecosystem services evaluated were previously selected from Stubbington et al. (2018b) and categorized as provisioning (i.e. freshwater, food from agriculture, food from livestock, fuelwood, health products), regulating (i.e. climate regulation, erosion control, fire regulation, flood-drought regulation, water-flow regulation, pollination, water quality regulation, nutrient cycling) and cultural ecosystem services (i.e. aesthetics values, education, recreation, sense of place, spiritual values). Later, we divided participants into three groups to discuss the results of the survey and reach a consensus about the perceived levels of importance of the ecosystem services listed. We then compared the results from the three groups to see the degree of agreement and/or differences in perceptions among them.

In the last part of the workshop, we used socio-cultural values to analyze inter-stakeholder conflicts that emerged from different perceptions towards ecosystem services in temporary rivers (Figure 1). Various participants, based on their expert knowledge, presented well-known conflicts and the group collectively selected two of them for an in-depth exploration. The participants, in two groups – one per case study and with the company of the expert on the correspondent conflict –, identified and defined the involved key stakeholders, and associated those ecosystem services that might be of interest to them. The participants then positioned each stakeholder group into a two-axes plot according to their influence on the management of the river and the breadth of interests, understood as the range of ecosystem services that are important for their well-being (Jorda-Capdevila 2016). Finally, the participants discussed key actions to overcome their respective social conflict.

**Table 1.** Main attributes of the workshop participants.

Attributes	Participants
Country	1 Cyprus, 1 France, 1 Germany, 1 Greece, 1 Italy, 1 Lithuania, 1 Malta, 1 Poland, 3 Portugal, 1 Serbia, 2 Spain, 1 Switzerland and 1 United Kingdom
Working area	3 river managers, 6 natural scientists, 2 social scientists and 5 interdisciplinary scientists.
Experience	7 juniors (under 8 years of experience after the PhD graduation) and 9 seniors
Gender	9 women and 7 men





**Figure 1.** Dynamics of the workshop for addressing temporary rivers socio-cultural values.

### 3. Results

#### 3.1. Research needs regarding the social perception of temporary rivers

From the presentations and the subsequent discussion, multiple research needs emerged regarding the social perceptions of temporary rivers, which were grouped in six ‘big’ topics (Figure 2). The first topic was the valuation of ecosystem services. There, participants highlighted the need to undertake on-the-ground research on the economic and socio-cultural values of temporary rivers due to the scarcity of studies specifically targeting temporary rivers. Additionally, they pinpointed the need to conduct research in different geographical locations and explore the differences in the provision of ecosystem services.

Secondly, another research need related to the former was the trade-offs and synergies among different ecosystem services, which represent potential inter-stakeholder conflicts and alliances. Most participants mentioned the lack or the implementation of environmental flows in temporary rivers as an important and frequent cause of conflict.

Thirdly, the topic of public participation was also considered to be important for further research.

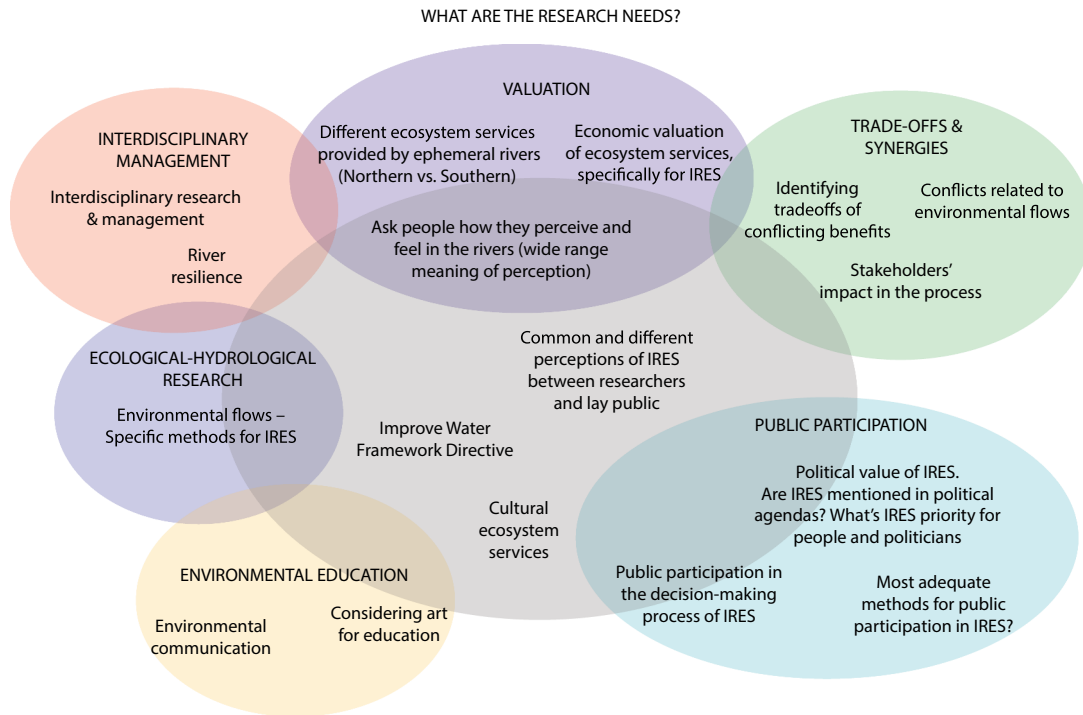
Participants expressed the need to assess the level of public participation in the decision-making processes related to temporary rivers. There was also a research need related to the political value of temporary rivers, meaning the place that temporary rivers occupy in political agendas and the priorities people and politicians have for temporary rivers.

Fourth, environmental education emerged as an important topic and referred mostly to environmental communication and the need to explore the use of a variety of communication tools, such as art.

The fifth topic was the improvement of ecological-hydrological research and the development of specific methods for adapting environmental flow methodologies to temporary rivers.

Finally, the sixth big topic was an overall need to promote and implement interdisciplinary research and management, and the study of the resilience of temporary rivers to natural and human disturbances.

Lastly, there were three research needs that were considered ‘bridges’ among the big topics specified above. First, participants found relevant the study of cultural ecosystem services for valuation and as a key tool to explore trade-offs and synergies. Cultural ecosystem services could also be key to environmental education and public participation. Second, the



**Figure 2.** Needs for next research steps about temporary rivers grouped in six 'big' topics. IRES: 'Intermittent rivers and ephemeral streams', which is the term used in different scientific contexts for temporary rivers.

improvement of the European Water Framework Directive could be strengthened by ecological-hydrological research on environmental flows, but also by the study of trade-offs and synergies, public participation and valuation. Finally, the exploration of common and different perceptions of temporary rivers among researchers and the lay public would nourish valuation exercises, studies on trade-offs and synergies, participation, and interdisciplinary management.

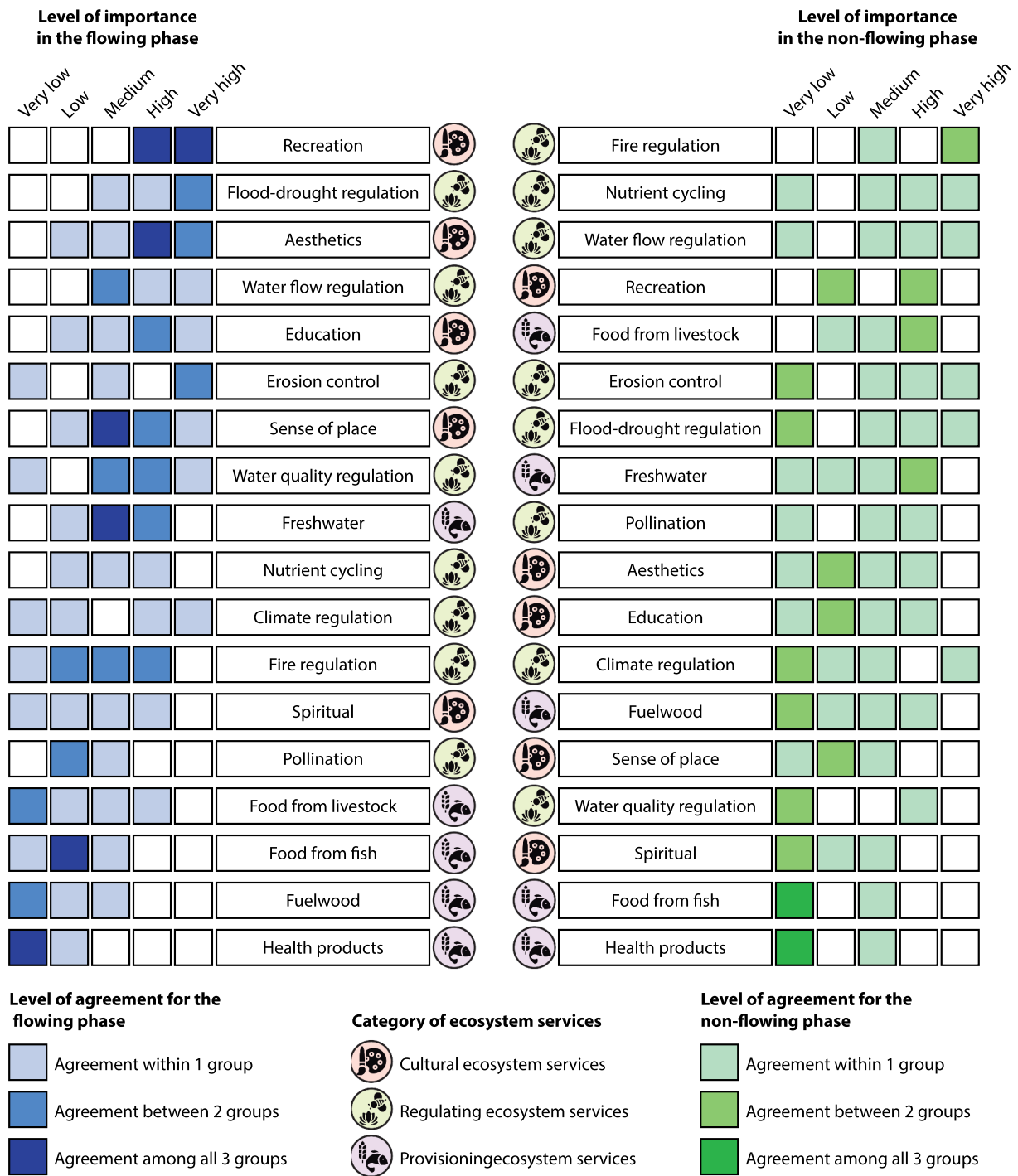
### 3.2. Socio-cultural valuation of temporary rivers ecosystem services

In this part of the workshop, we explored socio-cultural values, understood as to be the importance of ecosystem services for human well-being. We also identified the level of agreement among participant groups as an indicator for similarities or differences among geographical areas or stakeholder types. Our results showed different levels of importance varying across ecosystem services, but also different patterns of agreement. [Figure 3](#) shows the results after merging the results from the discussion of three different groups from the workshop. The cells marked in color denote levels of importance of ecosystem service and hydrological phase for at least one discussion group: blue for the flowing phase and green for the non-flowing phase. The intensity of the color indicates the level of

agreement among the groups. Thus, the light colors indicate divergences that may be due to among geographical contexts and/or stakeholder types while dark colors indicate certain convergence.

Overall, perceived importance was higher for regulating and cultural services and no provisioning service ever reached very high levels of importance. By comparing flowing and non-flowing phases, we observed that cultural ecosystem services were usually highly valued in the flowing phase rather than in the non-flowing phase. For the non-flowing phase, some regulating ecosystem services (e.g. fire regulation, pollination and nutrient cycling) and some provisioning services (e.g. food from livestock, freshwater and fuelwood) reached higher levels of importance. It is relevant to note that the importance of some ecosystem services like freshwater was higher in the non-flowing phase, what may indicate that its lower availability makes it perceive as more important.

Considering the agreement over the values of ecosystem services, most services ranged at least across three levels of importance, showing a diversity of values. This variation on the agreement likely indicates different knowledge bases or perceptions towards the same ecosystem services. For instance, in climate regulation, some people thought that the flowing phase acts as a carbon sink, but others that emits carbon or behaves as neutral. Regarding those ecosystem services whose perceived values got more agreement, we found



**Figure 3.** Level of importance of ecosystem services of temporary rivers in the flowing and non-flowing phases as perceived by workshop participants, and level of agreement among groups. Icons made by Freepik from [www.flaticon.com](http://www.flaticon.com).

food from fish, fire regulation, and water quality regulation in the non-flowing phase; pollination in the flowing phase; and health products and recreation in both phases. This level of agreement indicates that those services are overall important or not across most geographical zones or among different stakeholder groups. For instance, the agreement about the high importance of recreation in the flowing phase may indicate that overall local public consider recreational activities as important and this is homogeneous across different geographical areas.

### 3.3. Inter-stakeholder conflicts associated with socio-cultural values of ecosystem services provided by temporary rivers

We explored the potential conflicts emerging from different socio-cultural values of ecosystem services and levels of the influence on the management of the river in two case studies. To do so, participants proposed six conflicts they were familiar with, including an entanglement of tensions for the water use among irrigators, hydropower producers and advocates for

environmental flows; anti-dam struggles; social problems due to the effects of cattle farming in water quality and riparian vegetation; and competition between surface and groundwater users. Participants voted and selected two conflicts to work with. The first one explains the capture of the river flows by dam users in the Gaià River in Catalonia, Spain (see Box 1); the second confronts cattle farming and the water quality of the Degebe River in the Guadiana River basin, in Alentejo, Portugal (see Box 2).

Comparison of the Box 1 and 2 case studies show some similarities between both conflicts. Local

communities and government organization tend to have a more comprehensive perception in terms of ecosystem services, but their level of influence is low. Usually, business people are the most influential, like the oil company or the cattle farmers, but their level of breadth of interest may vary a lot. A common interest of those business people is the provisioning and regulating services. However, users interested in cultural ecosystem services are placed in medium-low levels of influence. Another common point between both case studies is that the tourist sector is the one with the narrowest interest and lowest influence.

**Box 1.** The kidnapping of the streamflow of the Gaià River (Catalonia, Spain).

The Gaià River used to have an intermittent flow regime – running during most of the time and dry in a number of days or weeks in summer – and is now ephemeral. This was before 1975, when the oil company Repsol Petróleo SA built a dam that completely captured the river flow –



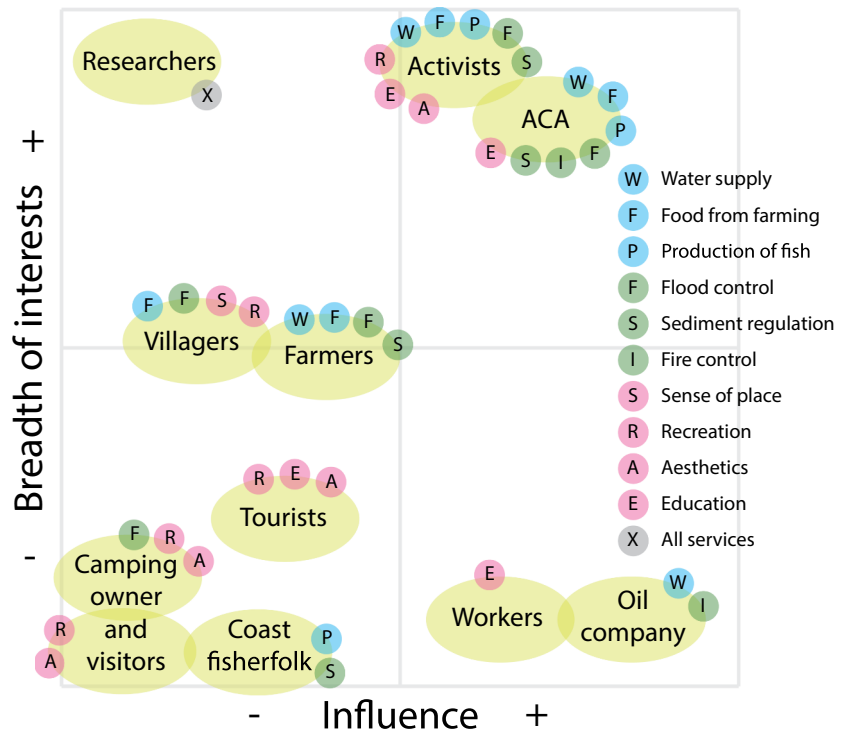
water and sediments –, leaving a low flow of water to cover irrigation purposes. The main goal of the dam was to store water for cooling the oil refinement processes. Consequently, beyond the deterioration of the river ecosystem, wells for drinking water became desiccated and the sediment contribution to coastal beaches interrupted by sediment trapping behind the dam.

In the 1990s, diverse organizations appeared and campaigned for an environmental flow and for the protection of the ecosystems associated with the Gaià River downstream of the dam (see Figure 4). In 1999, they created the platform ‘Salvem el Gaià’ and started to negotiate with the

**Figure 4.** Demonstration advocating for the environmental flows in the Gaià River in 2000. Source: Jordi Suñé, Coordinadora Salvem el Gaià.

Catalan Water Agency (ACA, for they acronym in Catalan) and Repsol. After many actions from activists, scientific studies and conferences, and a participatory process, the ACA and Repsol signed an agreement to discharge a new higher minimum flow (see more at ACA 2018). Two key reasons why Repsol acceded to such proposal were: firstly, the fact that the dam was constructed on a permeable geology, so 60% water infiltrates and becomes lost once the water level reaches a certain level and secondly, the oil industry got a new and much larger water source, so the water from the Gaià remained for emergency purposes only. Nowadays, Repsol discharges the minimum flow only when the reservoir exceeds a certain level, so depending on the environmental conditions, the Gaià River can experience both flowing water and no flow.

According to the results from our workshop (see Figure 5), some of the stakeholders involved in this conflict have a narrow interest in the river in terms of ecosystem services. Thus, Repsol is only interested in water supply and fire regulation to protect their industry, coastal fishing communities in sediment regulation and fish production, and the tourism sector in aesthetics and recreation mainly, but also on education and flood regulation. In contrast, the inhabitants of the riverine villages, and specially the environmentalist groups and the ACA have a more comprehensive interest in the river. Their interest includes all the ecosystem services mentioned before and, in addition, food from farming and sense of place, particularly important for the local population.



**Figure 5.** Influence-Breath of interest diagram of the conflict about the environmental flows in the Gaià River.



**Box 2.** Morphological transformation of the Degebe River for beef cattle purposes (Alentejo, Portugal).



**Figure 6.** The landscape of the Degebe River. Source: Maria Ilhéu.



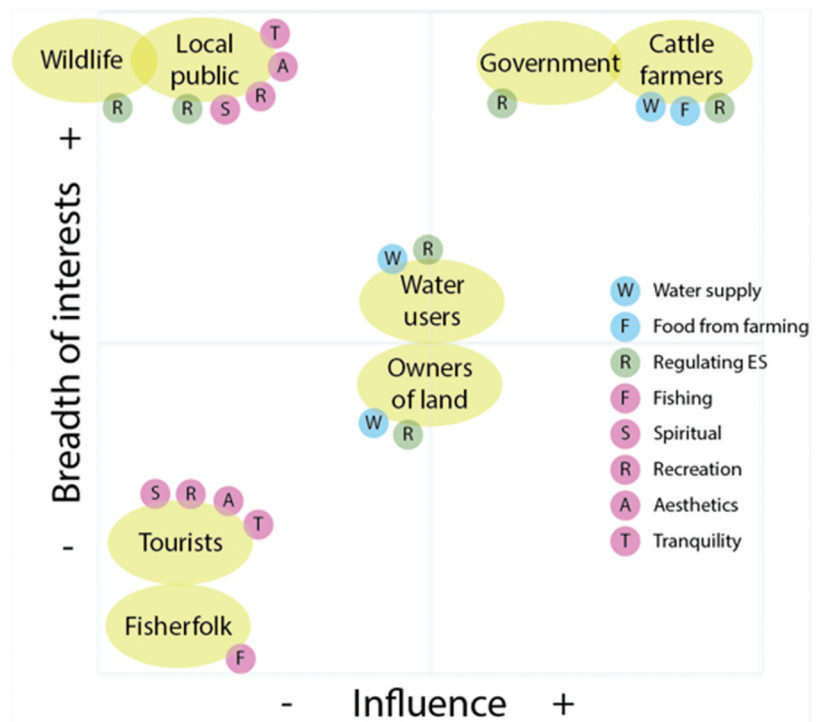
**Figure 7.** Impact on the water quality on the Degebe River. Source: Maria Ilhéu.

The Degebe River is a Mediterranean stream located in the Alentejo region of Portugal. It has high intra and inter-annual variation of precipitation and discharge, severe and unpredictable floods between autumn and spring, and persistent summer droughts. During the dry season, when the flow ceases, large sections of the streambed dry out or become reduced to isolated pools of variable size that remain as the only refuge for aquatic organisms until the reestablishment of the fluvial connectivity via the onset of river flow. Although this region is not highly populated, the rural landscape has been transformed by the agro-systems practices. Pastureland is now the largest land cover in terms of area. Pastures are mainly used as grazing area for livestock production (beef cattle), which has increased 42% in the last decade (INE 2011). The management of livestock is based on the rotational grazing of cattle. During the summer, when pastures become dry, livestock are often found in paddocks with free access to the streams, which are used as refuges from the heat and as drinking-water sources. In order to promote the cattle access to the stream water, livestock producers destroy the riparian gallery (particularly arboreal vegetation) and dig stream pools to promote groundwater into the stream that guarantees water provision along the summer (see Figures 6 and 7). These practices increase in-stream trampling and erosion due to overgrazed stream banks, decreasing bank stability. Moreover, the streams are also contaminated by nutrient-rich water runoff from adjacent land during and immediately after irrigation and precipitation, and by direct excretion of fecal material into the water (Matono et al. 2013).

All these pressures ultimately lead to water quality degradation and habitat disturbance and compromise the stream ecosystems services for users other than the landowners. In its functional and structural integrity, the Degebe River can provide a large number of ecosystems services, including cultural and recreational ones, for the local people, fisherfolk and tourists. In recent years, the Degebe River reaches impacted by livestock production look like a channel with muddy puddles rather than actually a river, which conditions the public perception on the ecosystem value, beyond the biophysical value itself.

Participants from the workshop discussions identified the Portuguese Government and cattle farmers as the most influential stakeholders (see Figure 8). This is because the Portuguese Civil code states that if a non-navigable river crosses a property, their bed and margins become private. This has led to different interests about the ecosystem services provided by the river. In this case, they are also the ones with a broader interest, since they are interested in all regulating

services, together with the local public and the wildlife – as a non-human stakeholder. Those owners that do not own cattle and water users that benefit from the freshwater and services related to the quality maintenance do not have the influence to prevent pollution. Finally, fishing communities and tourists are the stakeholder groups with less influence and breadth of interests, using only the stream for recreational and related purposes, and their wish is often neglected.



**Figure 8.** Influence-Breath of interest diagram of the conflict about the beef cattle use of the channel in the Degebe River.

## 4. Discussion

In the present paper, we have aimed to expand the knowledge about socio-cultural values of ecosystem services in temporary rivers. Although a few works on the ecosystem services of temporary rivers have recently emerged (Koundouri et al. 2017; Datry et al. 2018; Stubbington et al. 2018b, 2020; Jorda-Capdevila et al. 2020), our results pointed to different research gaps where socio-cultural valuation and socio-cultural values themselves can contribute to. They are the study of trade-offs and synergies, public participation, environmental education, and economic valuation of ecosystem services (Figure 2). Specifically, research about cultural ecosystem services was found to be central in the discussion on the research gaps identified in the workshop. In the socio-cultural valuation exercise, we demonstrated the importance of cultural ecosystem services in relation to the provisioning and regulating. We also explored how the socio-cultural values of temporary rivers change between flowing and non-flowing phases, although temporal variability of service provision goes beyond these two phases. Finally, the conflict analysis helped us to see the variety of social perceptions by positioning different stakeholder groups according to their level of influence and interest in the variety of services provided by temporary rivers. The following sections explore further the role of cultural ecosystem services on the socio-cultural value of temporary rivers and the temporal variability on the social perception of those values. The discussion ends by exploring the limitations of the current approach.

### 4.1. The contribution of cultural ecosystem services to the socio-cultural value of temporary rivers

Cultural ecosystem services are defined as nature's contribution to non-material benefits derived through human–ecosystem interactions (Chan et al. 2016) such as recreation, educational values, inspiration, aesthetic values, social relations (e.g. fishing societies), sense of place, cultural heritage (Russell et al. 2013). Despite the multiple ways that cultural ecosystem services contribute to the different dimensions of human well-being, the existing literature has mostly focused on analysing the contribution of recreational activities to economic welfare (Martínez Pastur et al. 2016). Moreover, the bulk of researchers working on temporary rivers come from natural sciences (see for instance the list of contributors in Jorda-Capdevila et al. 2020), which hampers the study of cultural services. Therefore, there seems to be a need for more research on other, less tangible, aspects of cultural ecosystem services and the

elicitation of their socio-cultural values (Russell et al. 2013; Chan et al. 2016). Accordingly, the participants of the workshop we organized identified cultural ecosystem services as one of the research areas that acts as a bridge in current research needs in the field of social perceptions of temporary rivers (see Figure 2).

Our results also show that cultural services are perceived as the most important ecosystem services provided by temporary rivers in the flowing phase, specifically the opportunities for various recreational activities (1st level of importance of 18 ecosystem services), the aesthetics (3rd), education (5th), and sense of place (7th). However, this level of importance drops to positions 4th, 10th, 11th and 14th, respectively, in the non-flowing phase. This is to be expected partially. On the one hand, this divergence between phase goes in line with the generalized perception that temporary rivers provide less ecosystem services than perennial rivers due to their non-flowing phase (Koundouri et al. 2017). On the other hand, cultural ecosystem services are the most dependent on the socio-cultural context and many cultural ecosystem services are associated to dry riverbeds as well (Steward et al. 2012).

The divergent perception towards cultural ecosystem services, represented as different results between phases but also as a lack of agreement in our results, is also a possible source of conflict and requires the exploration of the multiple stakeholder views. Hanacek et al. (2021) analyses the level of influence of actors involved in environmental conflicts over agroecosystems and found that this is intertwined with cultural ecosystem services. In fact, our results from the conflict analysis exercise show that those actors that benefit from cultural services are not the ones with a high level of influence in decision-making. In the two case studies analyzed, there seem to be trade-offs that include provisioning and regulating ecosystem services against cultural ones. This makes cultural ecosystem services of temporary rivers more vulnerable since the actors who are most interested in their conservation do not have enough influence to protect them from potential overuse or degradation. A more participatory management of temporary rivers could be one strategy to tackle this problem.

### 4.2. Temporal and geographical variability on the perception of socio-cultural values

Socio-cultural values are diverse, changing, and complex (Gibbs 2010). Efforts to acknowledge and incorporate the diversity of nature's values are being undertaken globally. However, values are usually represented as static rather than changing, and simple (discrete and readily categorized) rather than

complex and interconnected (Gibbs 2010). The question of variability in values seems particularly important in the case of temporary rivers for two reasons: (1) most of the values of ecosystem services vary seasonally and change between phases (Figure 3) and, (2) the construction of the values in each phase might be dependent on each other. The variation among seasons and phases become highly visible in our results about, for instance, food from livestock, since a dry riverbed is valued as corridors for the animals, especially in arid landscapes (Steward et al. 2012), while a flowing river is not. The synergy between flowing and non-flowing phases in the provision of ecosystem services is also demonstrated. For example, it is known that regulating services are closely dependent on organisms whose life cycle requires both dry and wet phases, such as the dependence of water quality regulation and nutrient cycling on desiccation-tolerant microbes (Febria et al. 2012; Stubbington et al. 2020).

Societal perception is something, however, that has not been studied in depth to date (but see Gibbs 2010). A service might be considered very important during the flowing phase because of the lack of provision in the dry phase or the opposite. Thus, the ecosystem service values are dynamic over time and space and require the combination of both phases. For example, in Australia, where there is a high diversity of temporary flow regimes (Kennard et al. 2010), Gibbs (2010) found that different social actors – Aboriginal people, scientists, and other people living in the area – valued the variability of the river in particular places and times. But the low service provision in one phase may also boost its level of importance, hence freshwater becoming more important in the non-flowing phase.

This points out to several avenues for research, given that the duration, timing and frequency of each phase could be relevant for the perception of the ecosystem services provided. Therefore, overall perception of ecosystem services might also differ among flow regimes. For instance, ephemeral rivers spend most of the time in a dry phase and only flow after significant precipitation events, while intermittent rivers combine dry and flowing phases with similar durations. In addition, there are quasi-permanent rivers, for example, in the Baltic countries, where freezing is more common but drying occurs occasionally. This hydrological variability of temporary rivers also shows us the need of researching about the importance of the extraordinary compared to the everyday state.

Within Europe, the diversity of the occurrence, river regimes and nature of dry periods of temporary rivers are also expected to influence the diverse attitude of residents and decision makers (Stubbington et al. 2018a). We expect values in the Mediterranean countries, where they occur relatively often

(Skoulidakis et al. 2017), to differ from those in Central or Northern Europe, more humid areas, with a relatively much longer flowing period. Temporary rivers in arid zones represent an important element of both landscape and culture. This clearly increases the awareness of their water regime and the possibility of benefitting from services during both flowing and dry periods. However, intermittency does not only depend on meteorological factors, but also on physical-geographical factors. That is the case of temporary rivers in Lithuania and the ‘winterbournes’ in the UK, where the geology (e.g. chalk or other porous rocks) and soil composition (e.g. gleysol) make smaller rivers dry out in summer.

Consistent with the temporal and geographical variability of temporary rivers and the associated socio-cultural values, in the workshop we found the research needs of elaborating environmental flow methods that preserve them. In this context, Acuña et al. (2020) actually propose methodological advances for the environmental flow assessments, which include the calculation of duration, timing and frequency of both dry and wet phases. In this sense, efforts for managing environmental flows should not only preserve healthy, resilient and biodiverse ecosystems, but also protect and restore the socially valued benefits they provide for people of all cultures. This should include their economies, sustainable livelihoods, and well-being (Arthington et al. 2018); and spatial and temporal flow variability plays a role in the complexity of ecosystem services provision (Jorda-Capdevila and Rodríguez-Labajos 2017), particularly in temporary rivers. In fact, our results from the social conflicts show that those actors that advocate for an environmental flow as a variable flow regime (following Poff et al. 1997) – water administration and activists – are actors with a broad interest in service provision.

#### **4.3. Limitations of the current approach for studying socio-cultural values of temporary rivers**

In this paper, we respond to the specific request from the temporary river community of the need to start to value the ecosystem services provided by temporary rivers. We also explore those challenges and opportunities that may come along with the valuation process. As Tadaki et al. (2017) suggest, there is a wide array of approaches for documenting and analyzing socio-ecological values now; and those approaches bring their own concepts, assumptions, and limitations. Thus, the socio-cultural valuation of nature acts as a particular ‘technology of participation’. Here, we acknowledge that the approach presented in this paper, while participatory and deliberative, excludes the views of other stakeholders and is biased towards the knowledge of researchers and managers. In fact, we



are aware we are losing details of the assessed values. In this sense, future studies should cover social perceptions of local population (covering different stakeholder groups) related to temporary rivers. An additional limitation is the different geographical nature of temporary rivers in which participants are expert. The different ecosystem services values actually depend on their local experience. We build on the lack of knowledge about socio-cultural values toward temporary rivers in order to recommend place-based studies that cover and compare socio-cultural values across different regions and phases. That will be needed to better understand how values shift across temporal and spatial scales. However, we are not looking for single measurements of ecosystem services provided by temporary rivers. By making participants think about such measurements, we rather stimulate discussion about the particularities of ecosystem services of temporary rivers. We agree with Tadaki and Sinner (2014) in their cautioning against an approach to river governance where values are considered universal to humans and largely independent of the context in which they are situated because this particular approach to politics might legitimize some stakeholders' ways of knowing and certain developmental trajectories more than others.

## 5. Insights for research and management of temporary rivers

The general argument that temporary rivers are undervalued by society, from our point of view, might have to be reexamined under new light. We have shown that temporary rivers provide a wide range of ecosystem services that are valued differently depending on the water regime, flowing and non-flowing phases and season, but also on the stakeholder group, geographical origin, and socio-cultural context. Gibbs (2010) argues that this undervaluation of temporary rivers is primarily a function of a particular Eurocentric thinking where climatically temperate nature is normalized and nature under non-temperate climate is diagnosed as unnatural. Several consequences are derived by this limited view. For example, the Water Framework Directive in Europe was originally oriented to perennial rivers (Datry et al. 2014; Prat et al. 2014) and has been implemented with delay in EU Mediterranean countries. This is because, for temporary rivers, new tools and methods for hydrological and ecological status evaluation were needed (Nikolaidis et al. 2013). Other arguments about the undervaluation of temporary rivers can be found in our results. They show that the provisioning services, which are usually those of interest by the most influential stakeholders, are not at the top of the list of ecosystem services arranged by level of importance, while the most important are

cultural and regulating ecosystem services, more commonly associated with non-market values.

The next steps for research on ecosystem services provided by temporary rivers should be more comprehensive by incorporating a wider number of hydrological phases and their spatial and temporal distribution for ecosystem service provision. The effect of such distribution on social perception is also recommended to be analyzed. From our results, it is clear that considering only two 'end-member' phases (dry and wet phases) is not enough for understanding the complexity of ecosystem services provision or perception. There are many other phases (e.g. disconnected pools, connected pools, flood flows) that certainly play a role on biodiversity in temporary rivers (Spencer et al. 1999) and may be relevant for both provision and perception of ecosystem services. Some ecosystem services, such as those related to vegetation and pollination or aesthetic services might be enhanced in hydrologically intermediate phases such as the pool phase where plant growth is possible but not limited by water availability. If we do not include these phases, we are missing important elements of the perception.

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## Data availability statement

Raw data are archived on the Zenodo repository <https://zenodo.org/record/4680516#.YHQgw6xxdPY> (Jorda-Capdevila et al., 2021).

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## References

- ACA Agència Catalana de l'Aigua. 2018. The Gaià. [http://aca.gencat.cat/ca/laigua/proteccio-i-conservacio/cabals-de-manteniment/el-gaia/index.html#googtrans\(ca%7Cen\)](http://aca.gencat.cat/ca/laigua/proteccio-i-conservacio/cabals-de-manteniment/el-gaia/index.html#googtrans(ca%7Cen)).
- Acuña V, Datry T, Marshall J, Barceló D, Dahm CN, Ginebreda A, McGregor G, Sabater S, Tockner K, Palmer MA. 2014. Why should we care about temporary waterways? *Science*. 343(6175):1080–1081. doi:10.1126/science.1246666.
- Acuña V, Hunter M, Ruhí A. 2017. Managing temporary streams and rivers as unique rather than second-class ecosystems. *Biol Conserv*. 211:12–19. doi:10.1016/j.biocon.2016.12.025.
- Acuña V, Jorda-Capdevila D, Vezza P, De Girolamo AM, McClain ME, Stubbington R, Pastor AV, Lamouroux N, von Schiller D, Munné A, et al. 2020. Accounting for flow intermittency in environmental flows design. *J Appl Ecol*. 57(4):742–753. doi:10.1111/1365-2664.13590.
- Armstrong A, Stedman RC, Bishop JA, Sullivan PJ. 2012. What's a stream without water? Disproportionality in headwater regions impacting water quality. *Environ Manage*. 50(5):849–860. doi:10.1007/s00267-012-9928-0.
- Arthington AH, Bernardo JM, Ilhéu M. 2014. Temporary rivers: linking Ecohydrology, ecological quality and reconciliation ecology. *River Res Appl*. 30(10):1209–1215. doi:10.1002/rra.2831.
- Arthington AH, Bhaduri A, Bunn SE, Jackson SE, Tharme RE, Tickner D, Young B, Acreman M, Baker N, Capon S, et al. 2018. The Brisbane declaration and global action agenda on environmental flows. *Front Environ Sci*. 6:1–15. doi:10.3389/fenvs.2018.00045.
- Bastian O, Haase D, Grunewald K. 2012. Ecosystem properties, potentials and services - the EPPS conceptual framework and an urban application example. *Ecol Indic*. 21:7–16. doi:10.1016/j.ecolind.2011.03.014.
- Brummer M, Rodríguez-Labajos B, Thanh Nguyen T, Jordà-Capdevila D. 2017. “They have kidnapped our river”: Dam removal conflicts in Catalonia and their relation to ecosystem services perceptions. *Water Altern*. 10(3):744–768.
- Castro AJ, García-Llorente M, Martín-López B, Palomo I, Iniesta-Arandia I. 2013. Multidimensional approaches in ecosystem services assessment. In: Alcaraz-Segura D, Di Bella CM, Straschnoy JV, editors. *Earth observation of ecosystem services*. CRC Press; p. 442–461.
- Chan KMA, Balvanera P, Benessaiah K, Chapman M, Díaz S, Gómez-Baggethun E, Gould R, Hannahs N, Jax K, Klain S, et al. 2016. Why protect nature? Rethinking values and the environment. *Proc Natl Acad Sci*. 113(6):1462–1465. doi:10.1073/pnas.1525002113.
- Cottet M, Robert A, Datry T. 2019. “It's dry, it has less charms!” - how do perceptions of intermittent rivers influence the management of these complex socio-ecological systems. In: ISRS 2019 – Riverine Landscapes as Coupled Socio-Ecological Systems. Vienna (Austria).
- Datry T, Boulton AJ, Bonada N, Fritz K, Leigh C, Sauquet E, Tockner K, Hugueny B, Dahm CN. 2018. Flow intermittence and ecosystem services in rivers of the Anthropocene. *J Appl Ecol*. 55(1):353–364. doi:10.1111/1365-2664.12941.
- Datry T, Larned ST, Tockner K. 2014. Intermittent rivers: a challenge for freshwater ecology. *Bioscience*. 64(3):229–235. doi:10.1093/biosci/bit027.
- De Girolamo AM, Bouraoui F, Buffagni A, Pappagallo G, Lo Porto A. 2017. Hydrology under climate change in a temporary river system: potential impact on water balance and flow regime. *River Res Appl*. 33(7):1219–1232. doi:10.1002/rra.3165.
- De Girolamo AM, Lo Porto A, Pappagallo G, Tzoraki O, Gallart F. 2015. The hydrological status concept: application at a temporary river (Candelaro, Italy). *River Res Appl*. 31(7):892–903. doi:10.1002/rra.2786.
- Febria CM, Beddoes P, Fulthorpe RR, Williams DD. 2012. Bacterial community dynamics in the hyporheic zone of an intermittent stream. *Isme J*. 6(5):1078–1088. doi:10.1038/ismej.2011.173.
- Gibbs LM. 2010. “A beautiful soaking rain”: environmental value and water beyond Eurocentrism. *Environ Plan D Soc Sp*. 28(2):363–378. doi:10.1068/d9207.
- Hanaček H, Langemeyer J, Bileva T, Rodríguez-Labajos B. 2021. Understanding environmental conflicts through cultural ecosystem services - the case of agroecosystems in Bulgaria. *Ecol Econ*. 179:106834. doi:10.1016/j.ecolecon.2020.106834.
- Hanaček K, Rodríguez-Labajos B. 2018. Impacts of land-use and management changes on cultural agroecosystem services and environmental conflicts—A global review. *Global Environ Change*. 50:41–59. doi:10.1016/j.gloenvcha.2018.02.016.
- INE. 2011. *Recenciamento Agrícola 2009—Análise dos primeiros resultados*. Lisboa, Portugal.
- Iniesta-Arandia I, García-Llorente M, Aguilera PA, Montes C, Martín-López B. 2014. Socio-cultural valuation of ecosystem services: uncovering the links between values, drivers of change, and human well-being. *Ecol Econ*. 108:36–48. doi:10.1016/j.ecolecon.2014.09.028.
- Jorda-Capdevila D. 2016. *Water flows to multiple stakeholders: an ecosystem services-based approach to conflicts in the Ter River basin [Doctoral dissertation]*. Universitat Autònoma de Barcelona; <https://ddd.uab.cat/record/167831>
- Jorda-Capdevila D, Brummer M, Bruno D, Castanho AR, Antonio JC, Fortuño P, Jakubínský J, Kaletová T, Kelemen E, Koundouri P, et al. 2020. Ecosystem services and social perception. In: Magand C, Alves MH, Calleja E, Datry T, Dörflinger G, England J, Gallart F, Gómez R, Jorda-Capdevila D, Marti E, et al., editors. *Intermittent rivers and ephemeral streams: what water managers need to know*. Technical report – Cost ACTION, CA 15113. Version 1 ed. Genève: Zenodo; p. 85–105. 10.5281/zenodo.3888474.
- Jorda-Capdevila D, Rodríguez-Labajos B. 2017. Embracing complexity improves the assessment of environmental flows – one step beyond Gopal's (2016) framework. *Ecosyst Serv*. 25:79–81. doi:10.1016/j.ecoser.2017.03.018.

- Kaletová T, Loures L, Castanho RA, Aydin E, Da Gama JT, Loures A, Truchy A. 2019. Relevance of intermittent rivers and streams in agricultural landscape and their impact on provided ecosystem services—a Mediterranean case study. *Int J Environ Res Public Health*. 16 (15):2693. doi:10.3390/ijerph16152693.
- Keele V, Gilvear D, Large A, Tree A, Boon P. 2019. A new method for assessing river ecosystem services and its application to rivers in Scotland with and without nature conservation designations. *River Res Appl*. 35:1338–1358. doi:10.1002/rra.3533.
- Kennard MJ, Pusey BJ, Olden JD, Mackay SJ, Stein JL, Marsh N. 2010. Classification of natural flow regimes in Australia to support environmental flow management. *Freshw Biol*. 55 (1):171–193. doi:10.1111/j.1365-2427.2009.02307.x.
- Kenter JO, O'Brien L, Hockley N, Ravenscroft N, Fazey I, Irvine KN, Reed MS, Christie M, Brady E, Bryce R, et al. 2015. What are shared and social values of ecosystems? *Ecol Econ*. 111:86–99. doi:10.1016/j.ecolecon.2015.01.006.
- Koundouri P, Boulton AJ, Datry T, Souliotis I. 2017. Ecosystem services, values, and societal perceptions of intermittent rivers and ephemeral streams. In: Datry T, Bonada N, Boulton J, editors. *Intermittent rivers and ephemeral streams: ecology and management*. Academic Press: p. 455–476. doi: 10.1016/B978-0-12-803835-2.00018-8.
- Leigh C, Boersma KS, Galatowitsch ML, Milner VS, Stubbington R. 2019. Are all rivers equal? The role of education in attitudes towards temporary and perennial rivers. *People Nat*. pan3.22. doi:10.1002/pan3.22.
- Leigh C, Boulton AJ, Courtwright JL, Fritz K, May CL, Walker RH, Datry T. 2016. Ecological research and management of intermittent rivers: an historical review and future directions. *Freshw Biol*. 61(8):1181–1199. doi:10.1111/fwb.12646.
- Logar I, Brouwer R, Paillex A. 2019. Do the societal benefits of river restoration outweigh their costs? A cost-benefit analysis. *J Environ Manage*. 232:1075–1085. doi:10.1016/j.jenvman.2018.11.098.
- Martínez Pastur G, Peri PL, Lencinas MV, García-Llorente M, Martín-López B. 2016. Spatial patterns of cultural ecosystem services provision in Southern Patagonia. *Landsc Ecol*. 31 (2):383–399. doi:10.1007/s10980-015-0254-9.
- Matono P, Sousa D, Ilhéu M. 2013. Effects of land use intensification on fish assemblages in Mediterranean climate streams. *Environ Manage*. 52(5):1213–1229. doi:10.1007/s00267-013-0152-3.
- Nikolaidis NP, Demetropoulou L, Froebrich J, Jacobs C, Gallart F, Prat N, Lo PA, Campana C, Papadoulakis V, Skoulikidis N, et al. 2013. Towards sustainable management of Mediterranean river basins: policy recommendations on management aspects of temporary streams. *Water Policy*. 15(5):830–849. doi:10.2166/wp.2013.158.
- Poff NL, Allan JD, Bain MB, Karr JR, Prestegard KL, Richter BD, Sparks RE, Stromberg JC. 1997. The natural flow regime. A paradigm for river conservation and restoration. *Bioscience*. 47:769–784. doi:10.2307/1313099.
- Prat N, Gallart F, Von Schiller D, Polesello S, García-Roger EM, Latron J, Rieradevall M, Llorens P, Barberá GG, Brito D, et al. 2014. The mirage toolbox: an integrated assessment tool for temporary streams. *River Res Appl*. 30:1318–1334. doi:10.1002/rra.2757.
- Rodríguez-Lozano P, Woelfle-Erskine C, Bogan MT, Carlson SM. 2020. Are non-perennial rivers considered as valuable and worthy of conservation as perennial rivers? *Sustainability*. 12(14):5782. doi:10.3390/su12145782.
- Russell R, Guerry AD, Balvanera P, Gould RK, Basurto X, Chan KMA, Klain S, Levine J, Tam J. 2013. Humans and nature: how knowing and experiencing nature affect well-being. *Annu Rev Environ Resour*. 38(1):473–502. doi:10.1146/annurev-environ-012312-110838.
- Skoulikidis NT, Sabater S, Datry T, Morais MM, Buffagni A, Dörfliinger G, Zogaris S, Del Mar Sánchez-montoya M, Bonada N, Kalogianni E, et al. 2017. Non-perennial Mediterranean rivers in Europe: status, pressures, and challenges for research and management. *Sci Total Environ*. 577:1–18. doi:10.1016/j.scitotenv.2016.10.147.
- Spencer M, Blaustein L, Schwartz SS, Cohen JE. 1999. Species richness and the proportion of predatory animal species in temporary freshwater pools: relationships with habitat size and permanence. *Ecol Lett*. 2(3):157–166. doi:10.1046/j.1461-0248.1999.00062.x.
- Steward AL, Von Schiller D, Tockner K, Marshall JC, Bunn SE. 2012. When the river runs dry: human and ecological values of dry riverbeds. *Front Ecol Environ*. 10(4):202–209. doi:10.1890/110136.
- Stubbington R, Acreman M, Acuña V, Boon PJ, Boulton AJ, England J, Gilvear D, Sykes T, Wood PJ. 2020. Ecosystem services of temporary streams differ between wet and dry phases in regions with contrasting climates and economies. *People Nature*. 2(3):660–677. doi:10.1002/pan3.10113.
- Stubbington R, Chadd R, Cid N, Csabai Z, Miliša M, Morais M, Munné A, Pařil P, Pešić V, Tziortzis I, et al. 2018a. Biomonitoring of intermittent rivers and ephemeral streams in Europe: current practice and priorities to enhance ecological status assessments. *Sci Total Environ*. 618:1096–1113. doi:10.1016/j.scitotenv.2017.09.137.
- Stubbington R, England J, Acreman M, Wood PJ, Westwood C, Boon P, Mainstone C, Macadam C, Bates A, House A, et al., 2018b. The natural capital of temporary rivers: characterising the value of dynamic aquatic-terrestrial habitats. *Valuing Nature Natural Capital Synthesis Reports*, VNP12.
- Tadaki M, Sinner J. 2014. Measure, model, optimise: understanding reductionist concepts of value in freshwater governance. *Geoforum*. 51:140–151. doi:10.1016/j.geoforum.2013.11.001.
- Tadaki M, Sinner J, Chan KMA. 2017. Making sense of environmental values: a typology of concepts. *Ecol Soc*. 22(1). doi:10.5751/ES-08999-220107.
- Thorp JH, Covich AP. 2015. Overview of inland water habitats, in: Thorp and Covich's freshwater invertebrates: ecology and general biology. Fourth ed. Elsevier Inc; p. 23–56.