



Adapting participatory processes in temporary rivers management

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ABSTRACT

The European Water Framework Directive (WFD) mandates to incorporate the participation of stakeholders and the general public in the development and updating of the river basin management plans. So far, the WFD implementation has been mainly focused on perennial rivers without considering temporary rivers properly, neither in biomonitoring programs nor participatory processes. This paper aims at adapting participatory processes in river basin management to enhance the inclusion of ecosystems with poor or no social recognition such as temporary rivers. To do so, we examined previous experiences of participatory processes conducted in the WFD and adapted them to propose and implement an approach for promoting stakeholders' engagement in temporary rivers. The approach is based on a collaborative leadership, includes multiple participatory engagement mechanisms, uses future global change scenarios and the concept of ecosystem services at different stages of the process, and aims at involving stakeholders not only in the proposal of measures stage but in the diagnosis of the ecological status. It also includes an evaluation of participants' satisfaction on the process. We tested our approach in temporary rivers from the Mediterranean region. We found that the combination of environmental education and citizen science activities, together with the inclusion of the ecosystem services concept, was the most useful way to raise awareness on the biodiversity and ecological value of temporary rivers and to promote stakeholders' engagement. Workshops conducted during the diagnosis stage played an important role in both including stakeholders' suggestions and increasing their knowledge on temporary rivers. Further, envisaging climate-related future scenarios allowed participants to incorporate measures that could tackle new and emerging pressures on these ecosystems. As future environmental changes will increase the proportion of rivers with temporary flow regimes, our approach can contribute to adapt current participatory processes to future needs.

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1. Introduction

Participatory processes are included in most international, regional and national environmental policies as a tool to engage society in decision-making (Aguirre-Muñoz et al., 2008; Razzaque, 2009). Such engagement ensures the consideration of economic, political, ecological, cultural and social aspects, and is key for defining realistic environmental targets and increasing the success of management actions (Carayannis and Campbell, 2010; Crowley et al., 2017). Participatory processes are usually built on comprehensive and holistic approaches in which all local community members and other interested parties are (Razzaque, 2009; Carayannis and Campbell, 2010) a wide variety of engagement mechanisms (Reed, 2008). The most commonly used participatory engagement mechanisms consist of surveys, interviews, workshops, scientific dissemination and environmental education activities (Reed, 2008; Videira et al., 2006), which can be applied alone or in combination. Recently, few initiatives have also included citizen science projects as a tool to increase public engagement in environmental decision-making (When et al., 2015; Gray et al., 2017; Mukhtanov et al., 2018). In addition, to better engage society in decision-making, increasing public awareness on environmental issues is key. In this sense, some processes also have incorporated the ecosystem services concept (Jorda-Capdevila et al., 2016) or envisage future scenarios related to management actions to tackle new and emerging pressures on the environment (Kallis et al., 2006; Quevauviller, 2011; Verkerk et al., 2017).

In the last decades, participatory processes have been incorporated in water-related policies to promote a more sustainable and equitable management of water resources and to freely and equally engage citizens in management (Carr, 2015; Hand et al., 2018). For example, in Europe, the Water Framework Directive (WFD) explicitly requests every member state to conduct participatory processes when elaborating river basin management plans (EC, 2000). Similarly, in the United States, the Environmental Protection Agency encourages public participation in different environmental and conservation management decisions, also including river basin management plans (RCRA, 2016).

Participatory processes have so far focused mostly on perennial rivers, remaining scarce in other freshwater ecosystems, such as temporary rivers (but see Conallin et al., 2018). Temporary rivers, those that recurrently stop flowing and may dry out completely, represent nearly 50 % of the current global river network and support several unique and endemic aquatic and terrestrial biota (Datry et al., 2017). Beyond providing ecosystem services typical of perennial rivers, temporary rivers provide additional services such as unique genetic material from endemic species or those specifically related to the dry phase (Datry et al., 2017). However, these ecosystems are still rarely recognized and their management is still in its infancy compared to that in perennial rivers (Datry et al., 2017). For example, temporary rivers are usually eluded by flow gauging networks (Gallart et al., 2016), not always incorporated in biomonitoring programs and their ecological quality is not fully assessed (Stubington et al., 2018). Besides, their wide spatial and temporal hydrological variability can produce misleading bio-assessment results (Soria et al., 2020). Moreover, in most cases, society seems to hold these rivers in low esteem and they are often associated to environmental degradation (Leigh et al., 2019). In this context, incorporating participatory processes in the management of temporary rivers could also contribute to increase their social recognition. Considering that many perennial rivers are expected to change to temporary flow regimes as a result of global change and increased human demands for water resources (Döll and Schmied, 2012; Datry et al., 2017), developing participatory processes in temporary rivers may help adapting current river management practices to future environmental changes.

Here, we aim at adapting participatory processes in river basin management to better consider the particular needs of ecosystems with low social recognition, such as temporary rivers. We first examine previous experiences of participatory processes under the WFD by

summarizing the main approaches and mechanisms used in the development of river basin management plans. Second, we propose an approach to be applied in temporary rivers based on information extracted from these experiences and specific requirements of these ecosystems. Third, we apply our approach in Mediterranean-climate temporary rivers from Spain. Finally, we emphasize the main challenges encountered, highlight the insights gained from this experience, and recommend its application to other poorly recognized ecosystems.

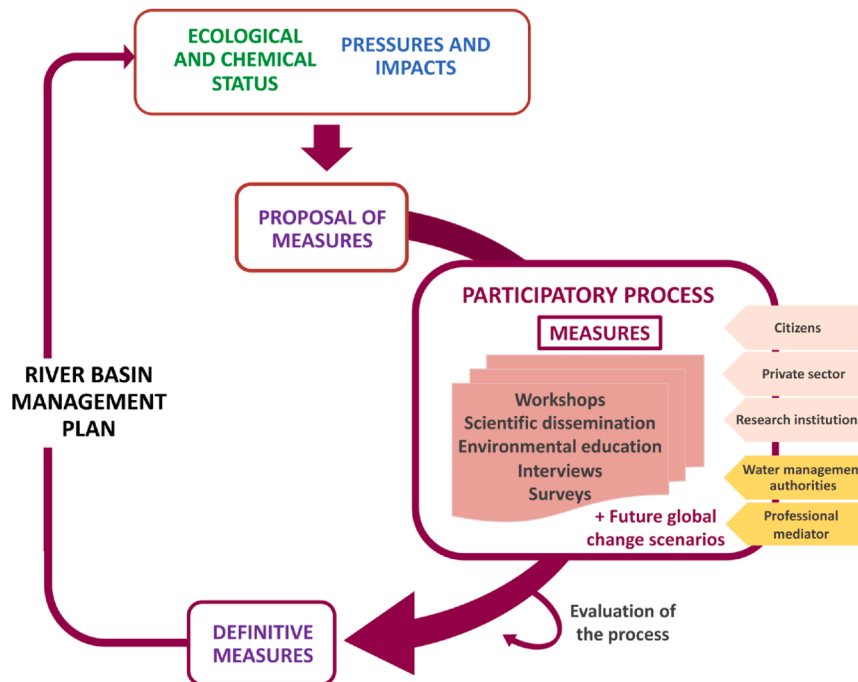
2. Participatory processes under the Water Framework Directive: approaches, mechanisms and inclusion of temporary rivers

In the European Union, the WFD provides a common framework for the management and protection of surface and ground water bodies (EC, 2000). It aims at achieving a 'good status' in water bodies, which is measured in terms of chemical and ecological status for surface waters, and chemical and quantitative status for groundwater (EC, 2000). The WFD mandates member states to define river basin districts as a management framework; designate their water bodies as artificial, heavily modified or natural; and implement river basin management plans (RBMP) and programs of measures (PoMs) to achieve their 'good status' (EC, 2000). The implementation proceeds in six-year cycles and requests the development and updating of both documents with the active involvement of stakeholders and the general public (EC, 2000) (Fig. 1a).

Even though recommendations on how to conduct participatory processes under the WFD exist (Commission of the European Communities (ComEC), 2003), there is still a lack of standardized methodology and information on the effectiveness of the different approaches and mechanisms (Newig and Koontz, 2014; Kochskämper et al., 2016; Boeuf and Fritsch, 2016). Notwithstanding, identifying the leadership of the process, the potential groups to be engaged (i.e. stakeholders), the timing for their incorporation and the mechanisms for their engagement are key aspects to be considered (Videira et al., 2006; De Stefano, 2010; Porter and Birdi, 2018). In addition, after conducting a participatory process, it is important to evaluate whether the process was perceived as satisfactory, and if there was a real influence on the planning process with tangible results (Videira et al., 2009; De Stefano, 2010; Kochskämper et al., 2016). Here, we scrutinized peer review publications on official participatory processes conducted since 2003 for the development and implementation of RBMPs and PoMs, which resulted in 23 records from 12 countries (see Appendix A1 for more details). We checked for the type of leadership, type of stakeholders participating and if they were incorporated at early stages of the process, the mechanisms used to engage them, and the evaluation of the participatory process. Regarding the mechanisms and tools used to engage stakeholders, we assessed the use of surveys, interviews, workshops, scientific dissemination, environmental educational activities and citizen science. For the evaluation of participatory processes, we assessed the satisfaction of participants in terms of their perception on the use of engagement mechanisms and leadership, and the real influence of the process on the planning process. In addition, we found convenient assessing if the concept of ecosystem services and future global change scenarios were considered, as previous studies showed their relevance to increase public awareness on rivers' current and future environmental decision-making (Kallis et al., 2006; Jorda-Capdevila et al., 2016). We also checked if any of the scrutinized publications included temporary rivers or not to assess their level of exclusion in participatory processes conducted in Europe.

As summarized in Table 1, three main type of leadership have been implemented in participatory processes from Europe: (a) lead by water management authorities, (b) collaborative leadership between research institutions and water management authorities, and (c) a bottom-up initiative from stakeholder's groups with no formal lead (Pahl-Wostl, 2006). Our synthesis on the participatory processes indicated that those lead by water management authorities or those with a collaborative

a) Participatory process within the WFD context



b) Our proposal

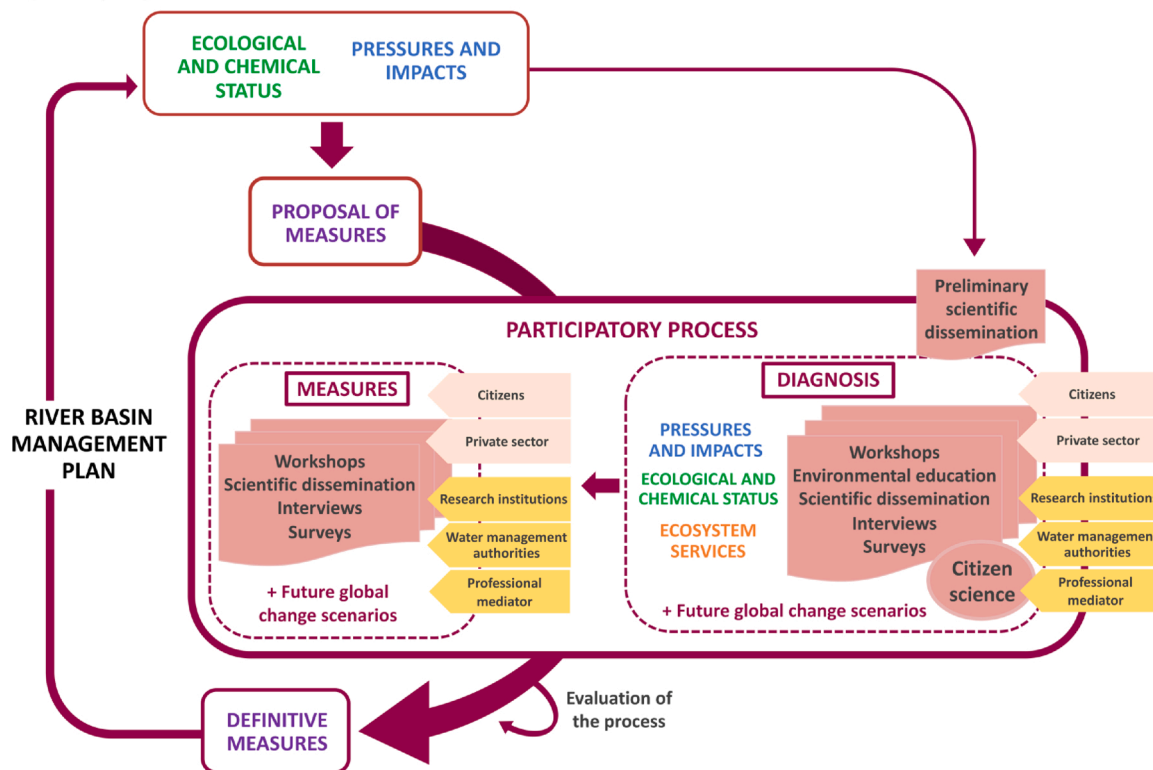


Fig. 1. Diagram on the approach of a participatory process in river basin management plans within the current WFD context (a), and our proposal to enhance the inclusion of temporary rivers (b). The leadership is indicated in yellow. Dashed lines indicate the two stages proposed within a participatory process: diagnosis and measures.

leadership were the most common, while only one case included a bottom-up initiative. Regarding the engagement of stakeholders, the Guidance on Public Participation from the WFD (Commission of the European Communities (ComEC, 2003) presents a list of potential groups, which include governmental administration (at European,

national, regional and local levels), professionals in the public and private sector, non-governmental organizations (NGOs) and individual citizens. In Table 1, we divided stakeholders as citizens, the public administration, research institutions and the private sector. Citizens include both the general public and specific sectors, such as local

Table 1
Participatory processes conducted in the context of the WFD linked to the development of official river basin management plans. They were classified by (a) type of leadership, (b) stakeholders' engagement, (c) timing of their involvement (i.e. whether stakeholders were included since the beginning of the process or not), (d) participatory engagement mechanisms used, (e) evaluation of the process, and by the consideration of (f) citizen science information, (g) future global change scenarios, (h) ecosystem services and (i) temporary rivers. na: data could not get from the article. See Appendix S1 for further details.

		Spain (Kallis et al., 2006)	Greece (Kallis et al., 2006)	Portugal (Videira et al., 2009)	Germany (Moellenkamp et al., 2010)	Denmark (Lieverink et al., 2011)	France (Lieverink et al., 2011)	The Netherlands (Lieverink et al., 2011)	Germany (Kochskämper et al., 2016)	Spain (Kochskämper et al., 2016)	United Kingdom (Kochskämper et al., 2016)
Type of leadership	Water management authorities	x	✓	x	x	✓	✓	x	✓	x	✓
	Collaborative	✓	x	✓	✓	x	x	x	x	✓	x
	Bottom-up initiative	x	x	x	x	x	x	✓	x	x	x
Type of stakeholders involved in the process	Citizens	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Public administration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Research institutions	✓	x	✓	✓	x	x	✓	x	✓	x
Inclusion of stakeholders at early stages of the process	Private sector	✓	✓	✓	✓	x	✓	✓	x	x	x
		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type of participatory engagement mechanisms	Workshop	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interview	✓	✓	✓	x	na	na	✓	x	x	x
	Survey	✓	x	x	✓	na	na	x	x	x	✓
	Scientific dissemination	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Environmental education	x	x	✓	x	x	x	x	x	x	x
Evaluation items	Satisfaction with the process	✓	✓	✓	✓	x	✓	✓	✓	✓	x
	Real influence	x	x	x	x	x	✓	✓	✓	x	x
Inclusion of citizen science information	x	x	x	x	x	x	x	x	x	x	x
Inclusion of future global change scenarios	x	✓	✓	x	x	x	✓	x	x	x	x
Inclusion of ecosystem services	x	x	x	✓	x	x	x	x	x	x	x
Inclusion of temporary rivers	x	x	x	x	x	x	x	x	x	x	x

associations, community groups and environmental NGOs. Public administrations include those related to the implementation of water management measures, such as the public water agencies or government-owned water companies, but also other local municipalities such as town and regional councils. Universities and entities/institutes related to the process were included in Table 1 as research institutions. The private sector includes agri-food and stock sectors, as well as medium-small farmers, tourism sector, private water managers and other possible water-related industries. Most case studies included citizens and governmental administration as stakeholders, whereas research institutions and the private sector were not always present (Table 1). Regarding the timing of incorporation of stakeholders, all case studies included them at early stages of the process (Table 1). Among the different mechanisms to engage stakeholders, the most common were interviews, surveys, workshops and scientific dissemination, but very few studies used a combination of more than three of them (Table 1). Environmental education was only used in one case and citizen science was not included in any of the studies. Participatory processes were perceived as satisfactory in most cases, except for 2 studies out of 10, for which stakeholders suggested that there was not enough time for questions and meaningful discussion (Kochskämper et al., 2016) or that the government limited their involvement and fell back to the aims already contained in the old plans (Lieverink et al., 2011). Only 3 studies out of 10 showed that there was a real influence on the planning process (Table 1). For the rest, the process was not perceived as fair due to the lack of influence on the planning process (e.g. Belfast Lough and Lagan basins in UK), or because the social context of the process ended up being just a first draft for further planning (e.g. Miera and Campiázo basins in Spain) (Kochskämper et al., 2016).

The ecosystem service concept was only included in one case with the objective of increasing public awareness on rivers (Table 1). Despite the WFD allows to incorporate climate-related water risks information when developing the RBMP (EC, 2009; Quevauviller, 2011), only two participatory processes envisaged clear future global change scenarios that could involve a deterioration (e.g. growth of mass tourism) or an improve of the status of water bodies (e.g. balanced development, emphasis on water conservation). Due to climate change being expected to reduce water availability, identifying future locally-relevant challenges for the management and adaptation of river basins is key (Verkerk et al., 2017). Finally, despite temporary rivers are common across the European river networks, especially in the Mediterranean Basin (Stubbington et al., 2018), none of the participatory processes included them (Table 1), evidencing the need to ensure their full consideration in RBMP.

3. Adapting participatory processes to temporary rivers

Temporary rivers are among the most underprotected and poorly managed of all freshwater ecosystems (Leigh et al., 2019). Due to the high hydrological variability of these ecosystems and the lack of gauging data, obtaining information of their hydrological regime (i.e. whether there are perennial or temporary) is way more complex. Integrating as many sources of information as possible is therefore key to improve its hydrological and ecological evaluation and, in turn, to implement specific measures. In this sense, the involvement of both local citizens and stakeholders can result in a powerful tool for a complete understanding of the hydrology of temporary rivers. In addition to biomonitoring-related difficulties, the lack of management and protection of these ecosystems may be partly because society usually holds them in low esteem and as synonym of environmental degradation (Acuña et al., 2017; Leigh et al., 2019). For instance, when analysing statements about rivers' aesthetic and recreational provision, more positive attitudes were observed towards perennial than temporary rivers (Leigh et al., 2019). This can negatively affect participatory processes conducted in temporary rivers, as stakeholder engagement might be more difficult and require greater efforts compared to perennial

rivers (Conallin et al., 2018; Leigh et al., 2019). Here we propose an approach that could benefit temporary river management adapting previous experiences conducted in Europe (section 2). Our approach builds on the idea of raising awareness on the biodiversity value of these ecosystems (Leigh et al., 2019) and on the ecosystem services they provide (Datry et al., 2017), combined with a strategic design of the participatory process to potentially achieve better social and decision-making outcomes. We argue that the following elements will be key to engage stakeholders in temporary rivers: (1) establishing a collaborative leadership of the process and accurately analyse the potential stakeholders to be involved, (2) using multiple participatory engagement mechanisms and tools, (3) incorporating future global change scenarios, (4) considering the concept of ecosystem services at different stages of the process, (5) involving stakeholders not only in the proposal of measures but also in the diagnosis of ecological status, and (6) evaluating the outcomes of the process (Fig. 1b).

3.1. A collaborative leadership of the process and an accurate analysis of stakeholders

The success or failure of a participatory process can be determined by how stakeholders with different backgrounds tackle a problem, e.g. role of power, views of environment vulnerability and management style (Gray, 2004; De Stefano, 2010; Porter and Birdi, 2018). In this sense, the collaboration between representatives from management, research and private consultants (i.e. professional mediators) in public participation can help approaching stakeholders' perspectives and facilitate the resolution of potential conflicts (Moellenkamp et al., 2010; Porter and Birdi, 2018). Thus, instead of a leadership conducted by water management authorities (Fig. 1a), we considered that a collaborative approach that includes other parties can offer a more adaptive water management (Fig. 1b). For example, water management authorities can bring existing networks of stakeholders, but they might lack procedural knowledge on how to design and conduct a participatory process (Kochskämper et al., 2016). Instead, research institutions can design and evaluate the participatory process from inception to end, and an external professional mediator (i.e. not related to any of the stakeholders) can help to align all the parties and coordinate all the activities (Moellenkamp et al., 2010; Kochskämper et al., 2016). Research institutions can also complement the evaluation conducted by water management authorities by providing information from other sources. This can be especially useful for processes involving temporary rivers because research institutions could provide key information on the hydrological and biological variability from these ecosystems to be applied by managers (i.e. where and when the river dries out or disconnected pools remain, and how this translates into biological community changes). We also recommend a more specific stakeholder analysis to identify representatives of all groups, with special emphasis on including citizens from the municipalities/towns near the study sites. These groups might be also aware of the hydrological variability of temporary rivers and of the anthropogenic impacts they receive. The stakeholder analysis can be done through a first round of surveys or interviews asking for their willingness to participate (Reed, 2008; De Stefano, 2010) and how often they visit the study sites.

3.2. Using multiple participatory engagement mechanisms and tools

The use of combined participatory engagement mechanisms and tools contributes to increase public awareness and knowledge about values and benefits of rivers (Kallis et al., 2006; Mostert et al., 2007). This is especially relevant in the case of temporary rivers, as stakeholders involved in the participatory process might not be aware of the biodiversity and ecological value of these ecosystems nor of their current status (Rodríguez-Lozano et al., 2020) and more efforts might be required to engage them. Moreover, obtaining information from these stakeholders is key (see section 3.1) and using different mechanisms and

tools could facilitate this process. Within all mechanisms, those that promote open and constructive dialogues between stakeholders can enhance individuals' problem-solving and decision-making skills and, thus, benefit the outcomes of the process (Videira et al., 2006; Varner, 2014; Mukhtanov et al., 2018). To maximize the exchange of information between participants, we consider that workshops should be the central participatory mechanism (Fig. 1a,b). In addition to workshops, complementary participatory engagement mechanisms that offer participants knowledge in the simplest and most dynamic way should be included, such as environmental education activities, scientific dissemination and other visual mechanisms such as video, photovoice or art-based, among others (Fig. 1a,b). For instance, scientific dissemination using information panels, leaflets, newspapers and online platforms can contribute to offer information on the status of these poorly recognised ecosystems and main pressures and impacts to the entire community, as well as increase public awareness and their interest in participating (Fig. 1b). Using surveys and interviews as supporting participatory mechanisms can also help to incorporate participants' contributions during workshops (Fig. 1a,b), as well as to conduct stakeholder analysis before the process begins (see section 3.1). Moreover, to include those stakeholders that cannot attend face-to-face workshops but may have relevant contributions to both the diagnosis and assessment of temporary rivers, the use of an online survey or interview can be useful. Indeed, the field of online public participation is in a growth phase with many emerging opportunities for all stakeholders, as it empowers and engages far more participants (Gray et al., 2017; Mukhtanov et al., 2018).

In addition, there are several on-going citizen science projects that can provide tools to be used along a participatory process of rivers (Gray et al., 2017; Mukhtanov et al., 2018; Krabbenhoft and Kashian, 2020). Some of them include features that can be especially useful to increase stakeholders' awareness and knowledge on temporary rivers, such as CrowdWater (CrowdWater website, 2020), The Barrier Tracker (Portal Amber International website, 2020), Stream Tracker (Stream Tracker website, 2020) or RiuNet (RiuNet website, 2020). Further, their use can also be useful to collect data of these ecosystems before the process starts and, thus, complement data provided by water management authorities or research institutions.

3.3. Incorporating future global change scenarios

Changes in biodiversity and ecosystem functioning caused by global change are affecting the ecological and chemical status of rivers and the ecosystem services they provide (Millennium ecosystem assessment (MA, 2005; Jorda-Capdevila et al., 2016). In this context, river basin management practices should be adapted to future environmental changes such as the increase of temporary flow regimes as a result of more extreme droughts and increased human demands for water resources (Döll and Schmied, 2012; Datry et al., 2017). Thus, the incorporation of future global change scenarios is key to ensure a more adaptive and integrated management of rivers (Kallis et al., 2006; Quevauviller, 2011). In fact, it is expected that member states implementing the WFD clearly demonstrate how global change projections have been considered in the pressures and impacts assessment, in the monitoring programmes, and in the PoMs (EC, 2009). In addition, focusing on a future goal can also help to energize brainstorming in the participatory process (Kallis et al., 2006). In our approach, we suggest that stakeholders identify which factors could involve a deterioration of the temporary rivers ecological status in the future, and incorporate this information when developing the RBMP and PoMs (see section 3.5). To do so, we propose to include a medium-long term scenario (e.g. > 20–30 years), which might vary depending on the characteristics of the river basin district and the member state (Kallis et al., 2006; Jager et al., 2016). We recommend considering both spatial and temporal hydrological variability of temporary rivers in these future scenarios. Additionally, expected changes on the delivery of ecosystem services could

also be incorporated (see section 3.4).

3.4. Incorporating the concept ecosystem services

Rivers provide essential ecosystem services, including provisioning, regulation and cultural services (Millennium ecosystem assessment (MA, 2005). In the case of temporary rivers, even when the riverbed is completely dry, they can offer services such as walking trails, a source of medicinal plants or migration corridors for animals (Datry et al., 2017). When developing the final PoMs, the prioritization of the measures usually consider the effects of management actions on the status of water bodies but not on the human well-being resulting from changes in the provision of ecosystem services (Terrado et al., 2016). The combination of both the status of water bodies and their ecosystem services conditions might help stakeholders to prioritize those optimal management actions according to the cost-effectiveness criteria required by the WFD and, thus, improve decision-making in selecting suitable measures and the implementation of RBMPs (Terrado et al., 2016). In addition, several studies have shown that incorporating the concept of ecosystem services in participatory processes of the WFD can contribute to increase public awareness on rivers' environmental and conservation issues, and to enhance participants' engagement (Jorda-Capdevila et al., 2016; Grizzetti et al., 2016). We therefore suggest incorporating the concept of ecosystem services during the participatory processes in temporary rivers and provide the necessary information for the participants to distinguish the most relevant ecosystem services provided by each water body, and link them with the management measures listed in the RBMP and PoMs (see section 3.5). We think that this step could strengthen participant's understanding of the impact of the proposed measures on the environment and, thus, represent a step forward for increasing social engagement in water-related decision making (Terrado et al., 2016). This might be especially relevant when adapting participatory processes to temporary rivers due to their inherent social-ecological complexity (Datry et al., 2017; Leigh et al., 2019). When working with temporary rivers, however, it should be taken into account that the perceived value of some of their ecosystem services (e.g. provision of subsurface drinking water, groundwater recharge) vary over time due to their hydrological variability and among climate regions (Stubbington et al., 2020). Moreover, factors such as whether participants live close to a temporary river, how often they visit these ecosystems and which leisure activities they do there might influence their perception (Rodríguez-Lozano et al., 2020). In this sense, cultural ecosystem services such as landscape aesthetics, cultural relevance, religion and spirituality, education and research, public use, way of transport and recreation seem to be easier to link with changes in the state of the environment by the general public and, thus, can better contribute to promoting awareness on these ecosystems (Jorda-Capdevila et al., 2020).

3.5. Involving stakeholders in the diagnosis before the proposal of measures

Effective decision-making in participatory processes requires access to relevant information but also the capacity to contribute with reliable information (Tippet et al., 2005; De Stefano, 2010). To develop this capacity, all participants should have an adequate level of empowerment about the topic (Mostert et al., 2007; Moellenkamp et al., 2010; Porter and Birdi, 2018). In addition, not only communication but active participation from all participants should be promoted since the beginning of the process, that is, knowledge of the topic should be transferred from water authorities to other stakeholders and vice versa. Therefore, knowledge should be held to be the product of processes on which all participants collaborate closely (Pouliot, 2009). In this sense, involving participants in the diagnosis and assessment of the target ecosystem could: (1) increment their knowledge before measures are proposed and discussed, (2) help to raise awareness on the biodiversity and ecological value of these ecosystems, and (3) provide

complementary data to water management authorities. This becomes even more important when conducting a participatory process in ecosystems with poor or no social recognition such as temporary rivers which, in turn, may lack monitoring data due to the lack of gauging stations in most of these ecosystems (Gallart et al., 2016). Our approach proposes to incorporate a river diagnosis step prior to the proposal of measures resulting in a two-stage participatory process: (1) diagnosis and (2) measures (Fig. 1b).

3.5.1. The diagnosis stage

The diagnosis stage aims at engaging stakeholders and gathering new information on the impacts and status of water bodies (i.e. hydrological, ecological and chemical status). To increment participants' knowledge and awareness on the water bodies to be worked on, we suggest to provide them all the available information on the status and impacts of these ecosystems (see section 3.2). Such information can be obtained from monitoring and/or research programs conducted by water management authorities and researchers, respectively, and, when available, from citizen science projects (Gray et al., 2017; Mukhtanov et al., 2018; Van Cauwenbergh et al., 2018). To gather new information of each water body from participants, they can contribute to their diagnosis by double-checking the information provided by the organizers and/or identifying new ones when necessary. In addition, an evaluation of ecosystem services (see section 3.4), together with an activity on future global change scenarios could be incorporated to complement the diagnosis (see section 3.3). We therefore suggest that participants identify which future factors could cause a deterioration of the status of water bodies and the ecosystem services they provide, as well as potential changes in the current pressures and impacts. As the use of multiple mechanisms is crucial to conduct a successful participatory process (see section 3.2), we also propose conducting an environmental education activity within the diagnosis workshop. One example could be organizing a short field trip to a temporary river nearby the workshop location using citizen science (see section 3.2). Including these complementary activities within the workshop could contribute to raise awareness on temporary river management, implement an adequate level of empowerment to all participants, and show them how they can contribute to the diagnosis in the future (Conallin et al., 2018).

3.5.2. The measures stage

The measures stage corresponds to the traditional participation process to review the PoMs before its implementation (EC, 2009). Typically, water agencies conduct a workshop in which all stakeholders and a mediators are involved (Fig. 1a,b). In this workshop, management measures are exposed by water agencies via scientific dissemination mechanisms (e.g. Liefferink et al., 2011; Kochskämper et al., 2016). In turn, participants provide their contributions to obtain a final prioritization of measures (EC, 2009). Compared to traditional workshops on measures, we suggest to incorporate the results gathered in the previous diagnosis workshop. To do so, participants can contribute by double-checking if impacts and pressures detected in the diagnosis workshop had measures from the RBMPs associated and/or by identifying new ones. Ideally, participants should be the same ones from the diagnosis workshop. To include ecosystem services (see section 3.4), we propose that the workshop includes activities where participants can link the proposed measures with their effects on the provision of selected ecosystem services. Future global-change scenarios identified in the diagnosis workshop can also be considered here. This can be done using different methods, such as reference ranking with criteria, relative preference ranking or pair-wise ranking (Anyagbunam et al., 2004). This will give stakeholders the opportunity to identify which measures could contribute the most to improve the status of water bodies.

3.6. Evaluating the outcomes of the participatory process

The evaluation of the outcomes is required to increase social learning

(i.e. learning from practice) on public participation in river management (Tippet et al., 2005; Mostert et al., 2007; Varner, 2014). Lessons learned from participatory processes of the WFD have shown the benefits and challenges in involving stakeholders (e.g. Videira et al., 2006; Kochskämper et al., 2016), but little is known about its effectiveness when incorporating temporary rivers. In this sense, regardless of the ecosystem considered, participants can be asked to identify the factors fostering or hindering the outcomes of the process, e.g. the role of stakeholder involvement, politics and institutions, opportunities for interaction, openness and transparency (Mostert et al., 2007; Parés et al., 2015). Considering previous experiences in Europe (Table 1), we suggest that any evaluation process should ask participants to: (1) conduct a short survey to evaluate whether the process was satisfactory (e.g. activities, leadership, timing, stakeholder engagement), and (2) evaluate whether there was a real impact of the participants' contributions to the RBMPs (e.g. which new measures were included). Finally, we suggest to share all the outcomes through both scientific literature and online databases (Varner, 2014).

4. A case study from Mediterranean-climate temporary rivers

Between June 2017 and May 2018 we conducted a participatory process and implemented the approach described in the previous section. Our process included Mediterranean-climate riverine water bodies belonging to 3 different river basin districts in Spain (Ebro, Júcar and the Catalan River Basin District). These water bodies were study sites of the project LIFE + TRivers (<http://www.lifetrivers.eu/>), which aimed at developing operational methods for implementing the WFD in temporary rivers. Eleven perennial and eleven temporary water bodies were included (Fig. S1). These 22 water bodies were grouped in 5 areas of participation: Girona, East Tarragona, West Tarragona, South Tarragona and Castelló and Valencia (Fig. S1). Overall, our participatory process included several local users (e.g. citizens living nearby the water body), nine local environmental associations and NGOs, two private entities, five research institutions, six local municipalities (i.e. town and regional councils), and two water management authorities (Table S1). Our participatory process developed dissemination activities before the participation process and implemented a collaborative leadership between water management authorities, research institutions and a professional mediator (see details in Appendix S2).

The diagnosis and measures workshops were structured as explained in section 3.5, but few specific aspects need to be highlighted. For the diagnosis workshop, we included all stakeholders except citizens, water management authorities' representatives to allow citizens and private sector stakeholders bring their opinions independently of the official constraints. In this workshop, researchers and the mediator exposed the four different main topics: management, hydrology, ecological status and ecosystem services (Fig. S2a,b). The concept of ecosystem services was explained to the participants focusing on cultural services. Then, the contributions on pressures and impacts of each water body from participants, as well as on cultural ecosystem services (see section 3.4), were conducted with a brainstorming dynamic (Anyagbunam et al., 2004) (Fig. S2c,d). Participants also identified which future factors related to global change and other anthropogenic impacts could involve a deterioration of the status of water bodies in future-scenarios (see section 3.3). For the sake of simplicity and comparisons purpose between areas of participation, participants' contributions and factors related to global change were grouped by general themes and divided in three main topics: management, hydrology and ecological status. To conclude the diagnosis workshop, an environmental education activity was conducted using the citizen science app RiuNet (Fig. S2e,f). Activities conducted in the diagnosis workshop resulted in participants identifying several pressures and impacts for each water body of each area of participation (Table S2). Moreover, several interviews on the hydrological regime and alterations were conducted to citizens inhabiting the study sites.

Most common contributions related to the management of pressures and impacts identified by participants were an absence of awareness programs and environmental education, a lack of involvement of the competent administrations for the conservation of temporary rivers, and a non-existence of measures to manage forests in the river basin and the riparian zone. Among the pressures and impacts related to hydrology, contributions were about a lack of control to regulate water use, an uncontrolled dumping, and an increase of water extractions. Contributions related to the ecological status were mostly about the presence of invasive species and limitations of sewage treatment plants in improving ecological status. Participants also identified 13 factors related with future global change scenarios that could involve a deterioration of these water bodies (Table S2). The most frequently selected factors in each area of participation were related to an increase of: (i) public use, (ii) invasive species, (iii) water contamination, (iv) lack of involvement of the competent administrations, and (v) absence of awareness campaigns (Fig. 2). Among cultural ecosystem services, participants identified the landscape aesthetic values as the most important one (Table S3). Spirituality and fishing-hunting cultural ecosystem services were never selected by participants. Differences in ecosystem services obtained by area were mainly related with the singularities of each site. For example, bath was identified as an important ecosystem service in areas where most of rivers were perennial and swimming was frequent. In contrast, in areas where temporary rivers had a low frequency of flow periods (i.e. ephemeral or episodic flow regimes prevailed), bath was omitted and hiking in riverbeds was the most common ecosystem service selected.

In the measures workshop participants contributed by double-checking whether impacts and pressures detected in the diagnosis workshop had associated measures and identified new ones when necessary (see section 3.5). Then, measures were prioritized according to which ones could help to mitigate climate-related future impacts on the ecosystems (Fig. S2g,h). To do so, participants assigned weights to measures (1= very effective, 2= effective). Among the measures identified by participants, eight were related to management, five to hydrology and four to the ecological status of water bodies (Table S2). The

most frequently selected measures were: (i) promote social and institutional awareness campaigns; (ii) improve the control of water concessions and extractions; (iii) improve invasive species management, and (iv) improve purification (Fig. 2). Measures related to the maintenance of cultural ecosystem services were also identified and linked to the proposed measures. Among cultural ecosystem services, landscape aesthetics and education-research were the most frequently linked to the proposed measures by face-to-face participants (Fig. 3). Landscape aesthetics ecosystem service was mostly linked to measures such as establishing clear guidelines for the conservation of the riverbed and its riverside vegetation or controlling water extractions or improving management of invasive species. Regards to education-research one, it was mostly linked to measures related to social and institutional awareness campaigns or improve public participation, but also to the improvement of management of invasive species.

At the end of both workshops, a short survey was conducted to allow participants to evaluate the quality and learnings of the process (see section 3.6). According these surveys, participants were highly satisfied with the whole process and the associated activities (Table S5). For example, satisfaction with the time schedule and duration of the activities, the use of multiple mechanisms, and the opportunity of give their opinions freely were all scored high. In relation to the evaluation of the stakeholders' engagement, participants suggested that the inclusion of the environmental education activity conducted through the RiuNet citizen science project was the most successful format to learn the main topics of the process and provided a helpful experience. Participants also evaluated positively that their contributions to the RBMPs were directly linked to a formal decision-making process.

In parallel, an online survey was developed to include the inputs of those stakeholders that were not able to attend. The design, structure and questions of these surveys were divided in sections following the contents of the face-to-face diagnosis and measures workshops. As a result, the most common contributions to the diagnosis of water bodies identified through online participants were about uncontrolled dumping, insufficient sewage treatment, lack of information about temporary

		CLIMATE-RELATED FUTURE IMPACTS												
		MANAGEMENT							HYDROLOGY			STATUS		
		Lack control of water extractions	Absence of awareness campaigns	Increase of erosion processes	Lack of involvement of administrations	Prioritization of economic interests	Decrease of riverine vegetation	Increase of public use	Modification of the WFD (less restrictive)	Increase of dry period and temperature	Increase of aquifer exploitation	Disappearance of other related ecosystems	Increase of invasive species	Increase of water contamination
M E A S U R E S	M A N A G E M E N T	Awareness campaigns												
		Dissemination of water status												
		Halt erosion processes												
		Improve public participation												
		Regulate access to rivers												
		Improve administrative management												
		Conservation of riverbeds												
		Control aggregates extraction												
	H Y D R O L O G Y	Control water concessions/extractions												
		Implement saving practices												
		Improve river connectivity												
		Implement ecological flows												
		Improve management of rain water												
	S T A T U S	Change the agricultural model												
		Control dumping/releases												
Management of invasive species														
Improve purification														

Selected in none (□), one (◻), two (◼) or three (■) areas of participation.

Fig. 2. Prioritization of measures according to their importance for mitigating future global change impacts on the studied water bodies. Frequency of selection of each measure identified by face-to-face participants in workshops. Measures are divided by management, hydrology and ecological status of water body.

		ECOSYSTEM SERVICES							
		Landscape aesthetics	Cultural relevance	Education and research	Public use	Way of transport	Hiking	Bath	Collecting
MEASURES	MANAGEMENT	Awareness campaigns	■	■	■	■		■	
		Dissemination of water status			■				
		Halt erosion processes	■	■				■	
		Improve public participation	■		■	■			■
		Regulate access to rivers	■			■			■
		Improve administrative management	■		■	■			■
		Conservation of riverbeds	■		■			■	■
		Control aggregates extraction	■					■	
	HYDROLOGY	Control water concessions/extractions	■						■
		Implement saving practices							
		Improve river connectivity	■						
		Implement ecological flows	■		■			■	■
		Improve management of rain water			■				
	STATUS	Change the agricultural model		■				■	
		Control dumping/releases							
		Management of invasive species	■		■	■		■	■
Improve purification		■					■		

Selected in none (□), one (◻), two (◼), three (◼) or four (■) areas of participation.

Fig. 3. Cultural ecosystem services detected by face-to-face participants in workshops in relation to the proposed measures. Measures were divided by management, hydrology and ecological status of water body.

ivers, poor management of riverine vegetation, illegal water extractions, regulation infrastructures, and invasive species (Table S6). Consequently, several climate-related future impacts were identified by online participants, where the most recurrent were related to an increase of the dry period and temperature and aquifer exploitations, but also to a lack of involvement of the competent administrations and an absence of awareness campaigns (Table S6). Among cultural ecosystem services, online participants also identified the landscape aesthetic values as the most important one. Concerning the measures, the most frequently ones were related to promote social and institutional awareness campaigns and public participation, control water concessions and extractions and improve river connectivity (Table S6).

Once the measures proposed by both face-to-face and online participants were collected, the two water management authorities involved analysed them and assessed their feasibility in terms of implementation (Table S2). This resulted in measures that were already considered in the PoMs of the RBMPs (58 %), new ones that could be accepted for the RBMPs of 2016–2021 (or will be accepted but are still studying how) (18 %), those that are responsibility of other administrations (i.e. local authorities or national and regional administration) (20 %), and those that should be rejected (4%) because they were not compliant with the planning purposes or because of technical, economic

or timing reasons. Some examples of the most relevant measures that were incorporated in RBMPs were those related to the eradication of invasive species, the implementation of ecological flows, and the improvement of the river connectivity and the wastewater treatment systems (Table S4). Finally, both water management authorities committed to incorporate these temporary water bodies in the next RBMPs (i.e. 2022–2027).

5. Lessons learnt and key messages

Our approach seems to ensure a more adaptive and integrated management of temporary rivers. Involving stakeholders not only in the proposal of measures stage but in the diagnosis of the ecological status has resulted key in our participatory process. Inputs from participants about the hydrological regime and alterations of temporary rivers were key to improve the diagnosis (Gallart et al., 2017) and, thus, to improve the related measures in the RBMPs. Indeed, interviews to the riverside inhabitants turned out to be a primary source of information, complementary to gauging records and aerial photographs (Gallart et al., 2017). Our results also suggested that using multiple mechanisms and the ecosystem service concept facilitated participatory decision-making process and increased inclusiveness. In fact, using environmental

education and citizen science activities was the most useful way to raise awareness of temporary rivers. Simple monitoring methods linked to management thresholds such as the RiuNet app kept local community directly involved with the surrounding temporary rivers. Nevertheless, we observed that public knowledge and awareness towards these ecosystems varied among areas of participation due to the singularities of each site, as also suggested in Leigh et al. (2019). This should be taken into account when promoting stakeholders' engagement with these ecosystems. For example, participants had a better understanding of temporary rivers in areas where these ecosystems were naturally ephemeral (or episodic) and they used to hike along their riverbeds. Thus, including the use of the cultural ecosystem services concept during the diagnosis stage of our process was key to increase public awareness on these ecosystems, especially in areas where they were undervalued (Jorda-Capdevila et al., 2020). Further, the use of the ecosystem services concept has increased since the second cycle of the RBMPs, but less evidence is available on their use in the development and updating of these RBMPs (Grizzetti et al., 2016). Despite water management authorities from several state members have high expectations for incorporating an ecosystem services approach in RBMPs, it is still in an explorative stage (Grizzetti et al., 2016).

Our approach has shown to be useful in participatory process including temporary rivers, but to promote its success it should always be adapted to the specific context of the region. For example, considering the institutional and political context, the pre-existing relationships between stakeholders, or the culture of national/local stakeholder involvement. In this sense, in some areas of participation we found a tense socio-political context due to the Catalan independence referendum that prevented some participants from attending. In other areas, difficulties were simply related to low population density. Furthermore, we observed that in areas of participation where there were not many local organizations nor NGOs, participation was lower compared to areas with strong associative network. Thus, we adapted the way of carrying out the activities according to the different characteristics of these areas of participation. In this sense, professional neutral mediators were key (Moellenkamp et al., 2010; Kochskämper et al., 2016). Another limitation observed in our participatory process was the low assistance of the private sector. For instance, agri-food and stock sectors (e.g. trade union, big industries, medium farmers) or the tourism sector did not attend. Thus, efforts to engage the private sector should be increased to obtain the engagement of 'all interested parties' equally, as promoted by the WFD (EC, 2009).

The WFD also expects member states to clearly demonstrate how global change projections have been considered in the pressures and impacts assessment in the RBMPs (EC, 2009), but does not include temporary rivers in the RBMPs. Given that temporary flow regimes are increasing as a result of global change and increased human demands for water resources, river basin management practices also should be adapted to these future environmental changes (Döll and Schmied, 2012; Datry et al., 2017). In this sense, the cyclical nature of the WFD implementation brings the opportunity for incorporating new experiences in European water governance. So, why are water management authorities still not incorporating temporary rivers properly neither in the RBMPs nor in its participatory processes? Perhaps the simplest explanation is that this issue is a matter of time. Considering the on-going climate-related factors, it is clear that it will be necessary to incorporate them in the near future. In this sense, adaptive management approaches, such as ours, have the potential to aid in providing the framework to consider the complexities of temporary river systems and improve the management of these systems. Nevertheless, further research is required to increase social learning on public participation of temporary rivers.

To conclude, we consider that our approach could be applied not only in temporary rivers but also in other ecosystems with poor or no social recognition, such as urban rivers, vernal pools, wetlands or peatlands. In addition, these ecosystems are usually underprotected

and/or not always included in biomonitoring programs, so less data is available. In this sense, incorporating knowledge from participants, as well as information from citizen science projects, can be key. Despite some participatory processes have been conducted in temporary rivers (Conallin et al., 2018), urban rivers (Moran et al., 2019), wetlands (Smrekar et al., 2020) or peatlands (Heli et al., 2019), processes in ecosystems such as perennial rivers, lakes or forests still predominate. Over the decades, these poorly recognised ecosystems have been degraded due to over exploitation of their resources and improper development activities. Since global change will further affect these vulnerable ecosystems, efforts to better consider them in management and conservation programs need to account for participatory processes too.

Authors' statements

M.S., N.B., A.B., I.V. and D.J-C conceived the ideas and designed the methodology, assisted by N.C. Data of the study case was analysed by M. S., A.B., I.V., D.J-C. and N.C. M.S., N.B., A.B., I.V., D.J-C and N.C. led the writing of the manuscript, and C.S., A.M., S-M.J., P.F., F.G., D.V., P.L, J. L, T.E and N.P. contributed to the drafts. All authors gave final approval for submission.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.envsci.2021.03.005>.

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