Title:

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.

KEYWORDS: temporary and intermittent rivers, public participation, river basin management plans, social learning, stakeholder engagement, Water governance.

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 at al., 2017). Participatory processes are usually built on comprehensive and holistic approaches in which all local community members and other interested parties are involved (Razzaque, 2009; Carayannis and Campbell, 2010), using 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; Mukhtarov 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

101 additional services such as unique genetic material from endemic species or those
102 specifically related to the dry phase (Datry et al., 2017). However, these ecosystems are
103 still rarely recognized and their management is still in its infancy compared to that in
104 perennial rivers (Datry et al., 2017). For example, temporary rivers are usually eluded
105 by flow gauging networks (Gallart et al., 2016), not always incorporated in
106 biomonitoring programs and their ecological quality is not fully assessed (Stubbington
107 et al., 2018). Besides, their wide spatial and temporal hydrological variability can
108 produce misleading bioassessment results (Soria et al., 2020). Moreover, in most cases,
109 society seems to hold these rivers in low esteem and they are often associated to
110 environmental degradation (Leigh et al., 2019). In this context, incorporating
111 participatory processes in the management of temporary rivers could also contribute to
112 increase their social recognition. Considering that many perennial rivers are expected to
113 change to temporary flow regimes as a result of global change and increased human
114 demands for water resources (Döll and Schmied, 2012; Datry et al., 2017), developing
115 participatory processes in temporary rivers may help adapting current river management
116 practices to future environmental changes.

117 Here, we aim at adapting participatory processes in river basin management to
118 better consider the particular needs of ecosystems with low social recognition, such as
119 temporary rivers. We first examine previous experiences of participatory processes
120 under the WFD by summarizing the main approaches and mechanisms used in the
121 development of river basin management plans. Second, we propose an approach to be
122 applied in temporary rivers based on information extracted from these experiences and
123 specific requirements of these ecosystems. Third, we apply our approach in
124 Mediterranean-climate temporary rivers from Spain. Finally, we emphasize the main

125 challenges encountered, highlight the insights gained from this experience, and
126 recommend its application to other poorly recognized ecosystems.
127
128
129 **2. Participatory processes under the Water Framework Directive: approaches,**
130 **mechanisms and inclusion of temporary rivers**
131 In the European Union, the WFD provides a common framework for the management
132 and protection of surface and ground water bodies (EC, 2000). It aims at achieving a
133 'good status' in water bodies, which is measured in terms of chemical and ecological
134 status for surface waters, and chemical and quantitative status for groundwater (EC,
135 2000). The WFD mandates member states to define river basin districts as a
136 management framework; designate their water bodies as artificial, heavily modified or
137 natural; and implement river basin management plans (RBMP) and programs of
138 measures (PoMs) to achieve their 'good status' (EC, 2000). The implementation
139 proceeds in six-year cycles and requests the development and updating of both
140 documents with the active involvement of stakeholders and the general public (EC,
141 2000) (Fig. 1a).
142 Even though recommendations on how to conduct participatory processes under
143 the WFD exist (ComEC, 2003), there is still a lack of standardized methodology and
144 information on the effectiveness of the different approaches and mechanisms (Newig
145 and Koontz, 2014; Kochskämper et al., 2016; Boeuf and Fritsch, 2016).
146 Notwithstanding, identifying the leadership of the process, the potential groups to be
147 engaged (i.e. stakeholders), the timing for their incorporation and the mechanisms for
148 their engagement are key aspects to be considered (Videira et al., 2006; De Stefano,
149 2010; Porter and Birdi, 2018). In addition, after conducting a participatory process, it is

150 important to evaluate whether the process was perceived as satisfactory, and if there
151 was a real influence on the planning process with tangible results (Videira et al., 2009;
152 De Stefano, 2010; Kochskämper et al., 2016). Here, we scrutinized peer review
153 publications on official participatory processes conducted since 2003 for the
154 development and implementation of RBMPs and PoMs, which resulted in 23 records
155 from 12 countries (see Appendix A1 for more details). We checked for the type of
156 leadership, type of stakeholders participating and if they were incorporated at early
157 stages of the process, the mechanisms used to engage them, and the evaluation of the
158 participatory process. Regarding the mechanisms and tools used to engage stakeholders,
159 we assessed the use of surveys, interviews, workshops, scientific dissemination,
160 environmental educational activities and citizen science. For the evaluation of
161 participatory processes, we assessed the satisfaction of participants in terms of their
162 perception on the use of engagement mechanisms and leadership, and the real influence
163 of the process on the planning process. In addition, we found convenient assessing if the
164 concept of ecosystem services and future global change scenarios were considered, as
165 previous studies showed their relevance to increase public awareness on rivers' current
166 and future environmental decision-making (Kallis et al., 2006; Jorda-Capdevila et al.,
167 2016). We also checked if any of the scrutinized publications included temporary rivers
168 or not to assess their level of exclusion in participatory processes conducted in Europe.
169 As summarized in Table 1, three main type of leadership have been
170 implemented in participatory processes from Europe: (a) lead by water management
171 authorities, (b) collaborative leadership between research institutions and water
172 management authorities, and (c) a bottom-up initiative from stakeholder's groups with
173 no formal lead (Pahl-Wostl, 2006). Our synthesis on the participatory processes
174 indicated that those lead by water management authorities or those with a collaborative

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 (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 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

200 involvement and fell back to the aims already contained in the old plans (Liefferink et
201 al., 2011). Only 3 studies out of 10 showed that there was a real influence on the
202 planning process (Table 1). For the rest, the process was not perceived as fair due to the
203 lack of influence on the planning process (e.g. Belfast Lough and Lagan basins in UK),
204 or because the social context of the process ended up being just a first draft for further
205 planning (e.g. Miera and Campiazo basins in Spain) (Kochskämper et al., 2016).
206 The ecosystem service concept was only included in one case with the objective
207 of increasing public awareness on rivers (Table 1). Despite the WFD allows to
208 incorporate climate-related water risks information when developing the RBMP (EC,
209 2009; Quevauviller, 2011), only two participatory processes envisaged clear future
210 global change scenarios that could involve a deterioration (e.g. growth of mass tourism)
211 or an improve of the status of water bodies (e.g. balanced development, emphasis on
212 water conservation). Due to climate change being expected to reduce water availability,
213 identifying future locally-relevant challenges for the management and adaptation of
214 river basins is key (Verkerk et al., 2017). Finally, despite temporary rivers are common
215 across the European river networks, especially in the Mediterranean Basin (Stubbington
216 et al., 2018), none of the participatory processes included them (Table 1), evidencing
217 the need to ensure their full consideration in RBMP.
218

219 **3. Adapting participatory processes to temporary rivers**

220 Temporary rivers are among the most underprotected and poorly managed of all
221 freshwater ecosystems (Leigh et al., 2019). Due to the high hydrological variability of
222 these ecosystems and the lack of gauging data, obtaining information of their
223 hydrological regime (i.e. whether there are perennial or temporary) is way more
224 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

275 the municipalities/towns near the study sites. These groups might be also aware of the
276 hydrological variability of temporary rivers and of the anthropogenic impacts they
277 receive. The stakeholder analysis can be done through a first round of surveys or
278 interviews asking for their willingness to participate (Reed, 2008; De Stefano, 2010)
279 and how often they visit the study sites.
280
281 **3.2. Using multiple participatory engagement mechanisms and tools**
282 The use of combined participatory engagement mechanisms and tools contributes to
283 increase public awareness and knowledge about values and benefits of rivers (Kallis et
284 al., 2006; Mostert et al., 2007). This is especially relevant in the case of temporary
285 rivers, as stakeholders involved in the participatory process might not be aware of the
286 biodiversity and ecological value of these ecosystems nor of their current status
287 (Rodríguez-Lozano et al., 2020) and more efforts might be required to engage them.
288 Moreover, obtaining information from these stakeholders is key (see section 3.1) and
289 using different mechanisms and tools could facilitate this process. Within all
290 mechanisms, those that promote open and constructive dialogues between stakeholders
291 can enhance individuals' problem-solving and decision-making skills and, thus, benefit
292 the outcomes of the process (Videira et al., 2006; Varner, 2014; Mukhtarov et al.,
293 2018). To maximize the exchange of information between participants, we consider that
294 workshops should be the central participatory mechanism (Fig. 1a,b). In addition to
295 workshops, complementary participatory engagement mechanisms that offer
296 participants knowledge in the simplest and most dynamic way should be included, such
297 as environmental education activities, scientific dissemination and other visual
298 mechanisms such as video, photovoice or art-based, among others (Fig. 1a,b). For
299 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; Mukhtarov 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; Mukhtarov 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 (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 (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

375 do there might influence their perception (Rodríguez-Lozano et al., 2020). In this sense,
376 cultural ecosystem services such as landscape aesthetics, cultural relevance, religion and
377 spirituality, education and research, public use, way of transport and recreation seem to
378 be easier to link with changes in the state of the environment by the general public and,
379 thus, can better contribute to promoting awareness on these ecosystems (Jorda-
380 Capdevila et al., *in revision*).
381
382 **3.5. Involving stakeholders in the diagnosis before the proposal of measures**
383 Effective decision-making in participatory processes requires access to relevant
384 information but also the capacity to contribute with reliable information (Tippet et al.,
385 2005; De Stefano, 2010). To develop this capacity, all participants should have an
386 adequate level of empowerment about the topic (Mostert et al., 2007; Moellenkamp et
387 al., 2010; Porter and Birdi, 2018). In addition, not only communication but active
388 participation from all participants should be promoted since the beginning of the
389 process, that is, knowledge of the topic should be transferred from water authorities to
390 other stakeholders and vice versa. Therefore, knowledge should be held to be the
391 product of processes on which all participants collaborate closely (Pouliot, 2009). In
392 this sense, involving participants in the diagnosis and assessment of the target
393 ecosystem could: (1) increment their knowledge before measures are proposed and
394 discussed, (2) help to raise awareness on the biodiversity and ecological value of these
395 ecosystems, and (3) provide complementary data to water management authorities. This
396 becomes even more important when conducting a participatory process in ecosystems
397 with poor or no social recognition such as temporary rivers which, in turn, may lack
398 monitoring data due to the lack of gauging stations in most of these ecosystems (Gallart
399 et al., 2016). Our approach proposes to incorporate a river diagnosis step prior to the

400 proposal of measures resulting in a two-stage participatory process: (1) diagnosis and
401 (2) measures (Fig 1b).
402
403 3.5.1. The diagnosis stage
404 The diagnosis stage aims at engaging stakeholders and gathering new information on
405 the impacts and status of water bodies (i.e. hydrological, ecological and chemical
406 status). To increment participants' knowledge and awareness on the water bodies to be
407 worked on, we suggest to provide them all the available information on the status and
408 impacts of these ecosystems (see section 3.2). Such information can be obtained from
409 monitoring and/or research programs conducted by water management authorities and
410 researchers, respectively, and, when available, from citizen science projects (Gray et al.,
411 2017; Mukhtarov et al., 2018; Van Cauwenbergh et al., 2018). To gather new
412 information of each water body from participants, they can contribute to their diagnosis
413 by double-checking the information provided by the organizers and/or identifying new
414 ones when necessary. In addition, an evaluation of ecosystem services (see section 3.4),
415 together with an activity on future global change scenarios could be incorporated to
416 complement the diagnosis (see section 3.3). We therefore suggest that participants
417 identify which future factors could cause a deterioration of the status of water bodies
418 and the ecosystem services they provide, as well as potential changes in the current
419 pressures and impacts. As the use of multiple mechanisms is crucial to conduct a
420 successful participatory process (see section 3.2), we also propose conducting an
421 environmental education activity within the diagnosis workshop. One example could be
422 organizing a short field trip to a temporary river nearby the workshop location using
423 citizen science (see section 3.2). Including these complementary activities within the
424 workshop could contribute to raise awareness on temporary river management,

425 implement an adequate level of empowerment to all participants, and show them how
426 they can contribute to the diagnosis in the future (Conallin et al., 2018).
427
428 3.5.2. The measures stage
429 The measures stage corresponds to the traditional participation process to review the
430 PoMs before its implementation (EC, 2009). Typically, water agencies conduct a
431 workshop in which all stakeholders and a mediators are involved (Fig. 1a,1b). In this
432 workshop, management measures are exposed by water agencies via scientific
433 dissemination mechanisms (e.g. Lieffrink et al., 2011; Kochskämper et al., 2016). In
434 turn, participants provide their contributions to obtain a final prioritization of measures
435 (EC, 2009). Compared to traditional workshops on measures, we suggest to incorporate
436 the results gathered in the previous diagnosis workshop. To do so, participants can
437 contribute by double-checking if impacts and pressures detected in the diagnosis
438 workshop had measures from the RBMPs associated and/or by identifying new ones.
439 Ideally, participants should be the same ones from the diagnosis workshop. To include
440 ecosystem services (see section 3.4), we propose that the workshop includes activities
441 where participants can link the proposed measures with their effects on the provision of
442 selected ecosystem services. Future global-change scenarios identified in the diagnosis
443 workshop can also be considered here. This can be done using different methods, such
444 as reference ranking with criteria, relative preference ranking or pair-wise ranking
445 (Anyaegbunam et al., 2004). This will give stakeholders the opportunity to identify
446 which measures could contribute the most to improve the status of water bodies.
447
448 **3.6. Evaluating the outcomes of the participatory process**

449 The evaluation of the outcomes is required to increase social learning (i.e. learning from
450 practice) on public participation in river management (Tippet et al., 2005; Mostert et al.,
451 2007; Varner, 2014). Lessons learned from participatory processes of the WFD have
452 shown the benefits and challenges in involving stakeholders (e.g. Videira et al., 2006;
453 Kochskämper et al., 2016), but little is known about its effectiveness when
454 incorporating temporary rivers. In this sense, regardless of the ecosystem considered,
455 participants can be asked to identify the factors fostering or hindering the outcomes of
456 the process, e.g. the role of stakeholder involvement, politics and institutions,
457 opportunities for interaction, openness and transparency (Mostert et al., 2007; Parés et
458 al., 2015). Considering previous experiences in Europe (Table 1), we suggest that any
459 evaluation process should ask participants to: (1) conduct a short survey to evaluate
460 whether the process was satisfactory (e.g. activities, leadership, timing, stakeholder
461 engagement), and (2) evaluate whether there was a real impact of the participants'
462 contributions to the RBMPs (e.g. which new measures were included). Finally, we
463 suggest to share all the outcomes through both scientific literature and online databases
464 (Varner, 2014).
465
466
467 **4. A case study from Mediterranean-climate temporary rivers**
468 Between June 2017 and May 2018 we conducted a participatory process and
469 implemented the approach described in the previous section. Our process included
470 Mediterranean-climate riverine water bodies belonging to 3 different river basin
471 districts in Spain (Ebro, Júcar and the Catalan River Basin District). These water bodies
472 were study sites of the project LIFE+ TRivers (http://www.lifetrivers.eu/), which aimed
473 at developing operational methods for implementing the WFD in temporary rivers.

474 Eleven perennial and eleven temporary water bodies were included (Fig. S1). These 22
475 water bodies were grouped in 5 areas of participation: Girona, East Tarragona, West
476 Tarragona, South Tarragona and Castelló and Valencia (Fig. S1). Overall, our
477 participatory process included several local users (e.g. citizens living nearby the water
478 body), nine local environmental associations and NGOs, two private entities, five
479 research institutions, six local municipalities (i.e. town and regional councils), and two
480 water management authorities (Table S1). Our participatory process developed
481 dissemination activities before the participation process and implemented a
482 collaborative leadership between water management authorities, research institutions
483 and a professional mediator (see details in Appendix S2).
484 The diagnosis and measures workshops were structured as explained in section
485 3.5, but few specific aspects need to be highlighted. For the diagnosis workshop, we
486 included all stakeholders except citizens, water management authorities' representatives
487 to allow citizens and private sector stakeholders bring their opinions independently of
488 the official constraints. In this workshop, researchers and the mediator exposed the four
489 different main topics: management, hydrology, ecological status and ecosystem services
490 (Fig. S2a,b). The concept of ecosystem services was explained to the participants
491 focusing on cultural services. Then, the contributions on pressures and impacts of each
492 water body from participants, as well as on cultural ecosystem services (see section
493 3.4), were conducted with a brainstorming dynamic (Anyaegbunam et al., 2004) (Fig.
494 S2c,d). Participants also identified which future factors related to global change and
495 other anthropogenic impacts could involve a deterioration of the status of water bodies
496 in future-scenarios (see section 3.3). For the sake of simplicity and comparisons purpose
497 between areas of participation, participants' contributions and factors related to global
498 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

524 frequent. In contrast, in areas where temporary rivers had a low frequency of flow
525 periods (i.e. ephemeral or episodic flow regimes prevailed), bath was omitted and
526 hiking in riverbeds was the most common ecosystem service selected.
527 In the measures workshop participants contributed by double-checking whether
528 impacts and pressures detected in the diagnosis workshop had associated measures and
529 identified new ones when necessary (see section 3.5). Then, measures were prioritized
530 according to which ones could help to mitigate climate-related future impacts on the
531 ecosystems (Fig. S2g,h). To do so, participants assigned weights to measures (1= very
532 effective, 2= effective). Among the measures identified by participants, eight were
533 related to management, five to hydrology and four to the ecological status of water
534 bodies (Table S2). The most frequently selected measures were: (i) promote social and
535 institutional awareness campaigns; (ii) improve the control of water concessions and
536 extractions; (iii) improve invasive species management, and (iv) improve purification
537 (Fig. 2). Measures related to the maintenance of cultural ecosystem services were also
538 identified and linked to the proposed measures. Among cultural ecosystem services,
539 landscape aesthetics and education-research were the most frequently linked to the
540 proposed measures by face-to-face participants (Fig. 3). Landscape aesthetics ecosystem
541 service was mostly linked to measures such as establishing clear guidelines for the
542 conservation of the riverbed and its riverside vegetation or controlling water extractions
543 or improving management of invasive species. Regards to education-research one, it
544 was mostly linked to measures related to social and institutional awareness campaigns
545 or improve public participation, but also to the improvement of management of invasive
546 species.
547 At the end of both workshops, a short survey was conducted to allow participants
548 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 rivers, 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., *in revision*). 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 RMBPs, 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

624 participants from attending. In other areas, difficulties were simply related to low
625 population density. Furthermore, we observed that in areas of participation where there
626 were not many local organizations nor NGOs, participation was lower compared to
627 areas with strong associative network. Thus, we adapted the way of carrying out the
628 activities according to the different characteristics of these areas of participation. In this
629 sense, professional neutral mediators were key (Moellenkamp et al., 2010;
630 Kochskämper et al., 2016). Another limitation observed in our participatory process was
631 the low assistance of the private sector. For instance, agri-food and stock sectors (e.g.
632 trade union, big industries, medium farmers) or the tourism sector did not attend. Thus,
633 efforts to engage the private sector should be increased to obtain the engagement of 'all
634 interested parties' equally, as promoted by the WFD (EC, 2009).
635 The WFD also expects member states to clearly demonstrate how global change
636 projections have been considered in the pressures and impacts assessment in the
637 RBMPs (EC, 2009), but does not include temporary rivers in the RBMPs. Given that
638 temporary flow regimes are increasing as a result of global change and increased human
639 demands for water resources, river basin management practices also should be adapted
640 to these future environmental changes (Döll and Schmied, 2012; Datry et al., 2017). In
641 this sense, the cyclical nature of the WFD implementation brings the opportunity for
642 incorporating new experiences in European water governance. So, why are water
643 management authorities still not incorporating temporary rivers properly neither in the
644 RBMPs nor in its participatory processes? Perhaps the simplest explanation is that this
645 issue is a matter of time. Considering the on-going climate-related factors, it is clear that
646 it will be necessary to incorporate them in the near future. In this sense, adaptive
647 management approaches, such as ours, have the potential to aid in providing the
648 framework to consider the complexities of temporary river systems and improve the

649 management of these systems. Nevertheless, further research is required to increase
650 social learning on public participation of temporary rivers.
651 To conclude, we consider that our approach could be applied not only in
652 temporary rivers but also in other ecosystems with poor or no social recognition, such as
653 urban rivers, vernal pools, wetlands or peatlands. In addition, these ecosystems are
654 usually underprotected and/or not always included in biomonitoring programs, so less
655 data is available. In this sense, incorporating knowledge from participants, as well as
656 information from citizen science projects, can be key. Despite some participatory
657 processes have been conducted in temporary rivers (Conallin et al., 2018), urban rivers
658 (Moran et al., 2019), wetlands (Smrekar et al., 2020) or peatlands (Heli et al., 2019),
659 processes in ecosystems such as perennial rivers, lakes or forests still predominate. Over
660 the decades, these poorly recognised ecosystems have been degraded due to over
661 exploitation of their resources and improper development activities. Since global change
662 will further affect these vulnerable ecosystems, efforts to better consider them in
663 management and conservation programs need to account for participatory processes too.
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665
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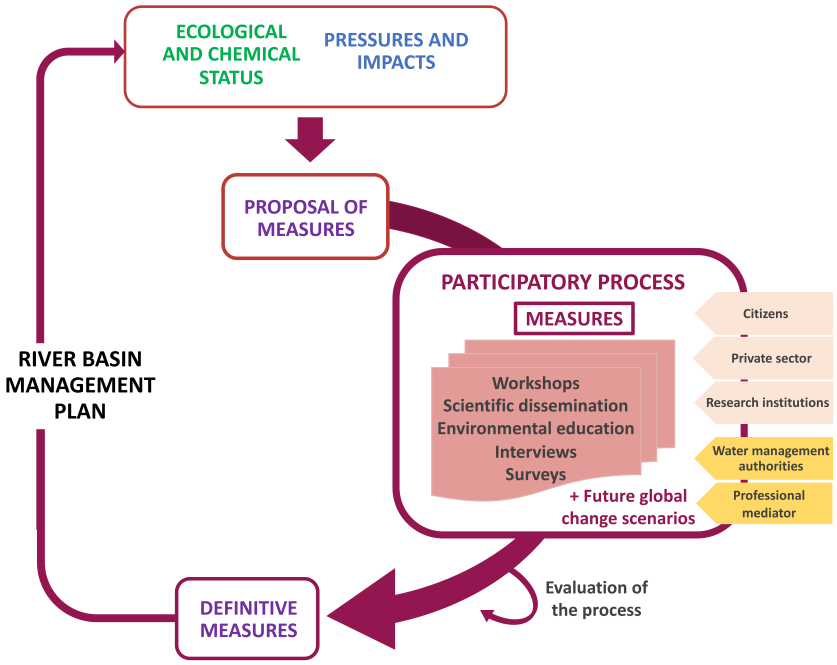
883

884 **FIGURES**

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

a) Participatory process within the WFD context



b) Our proposal

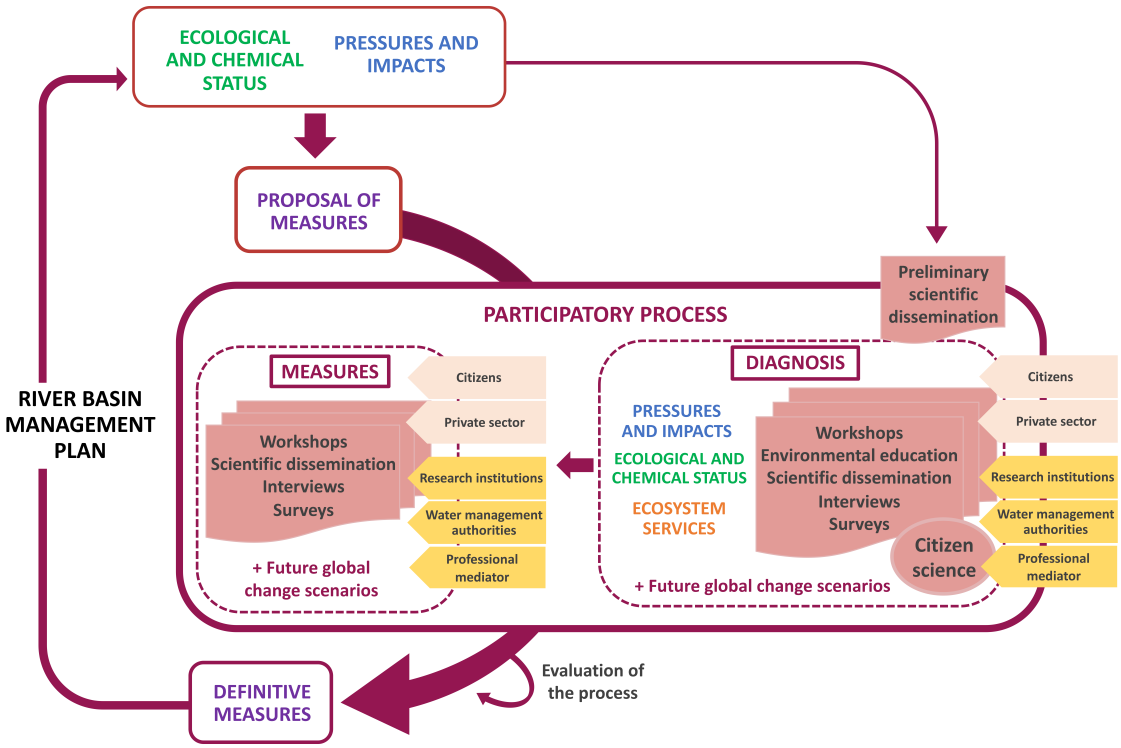


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Figure 2. Prioritization of measures according to their importance for mitigating future global change impacts on the studied water bodies. Frequency of selection of each measure identified by face-to-face participants in workshops. Measures are divided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

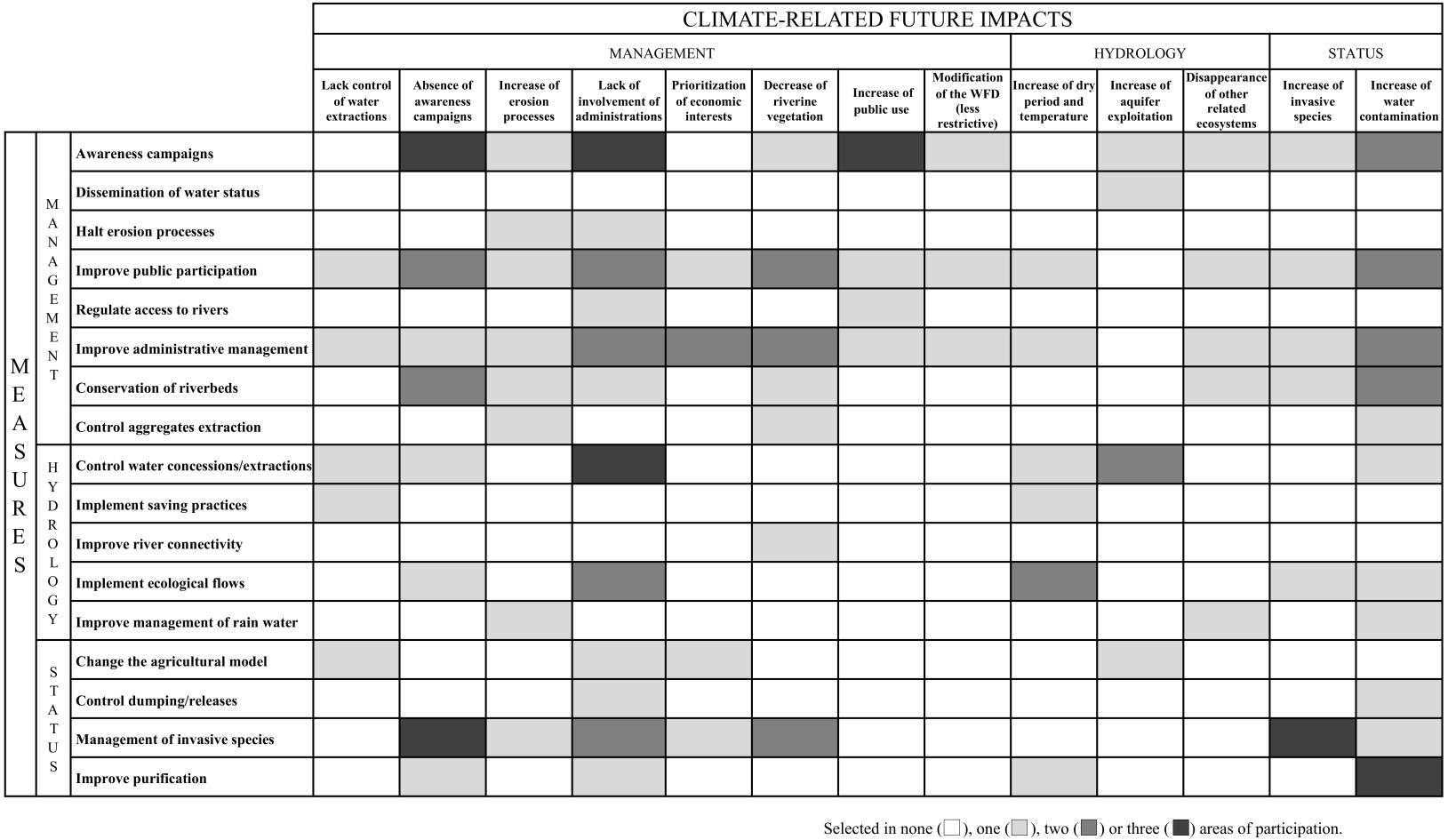
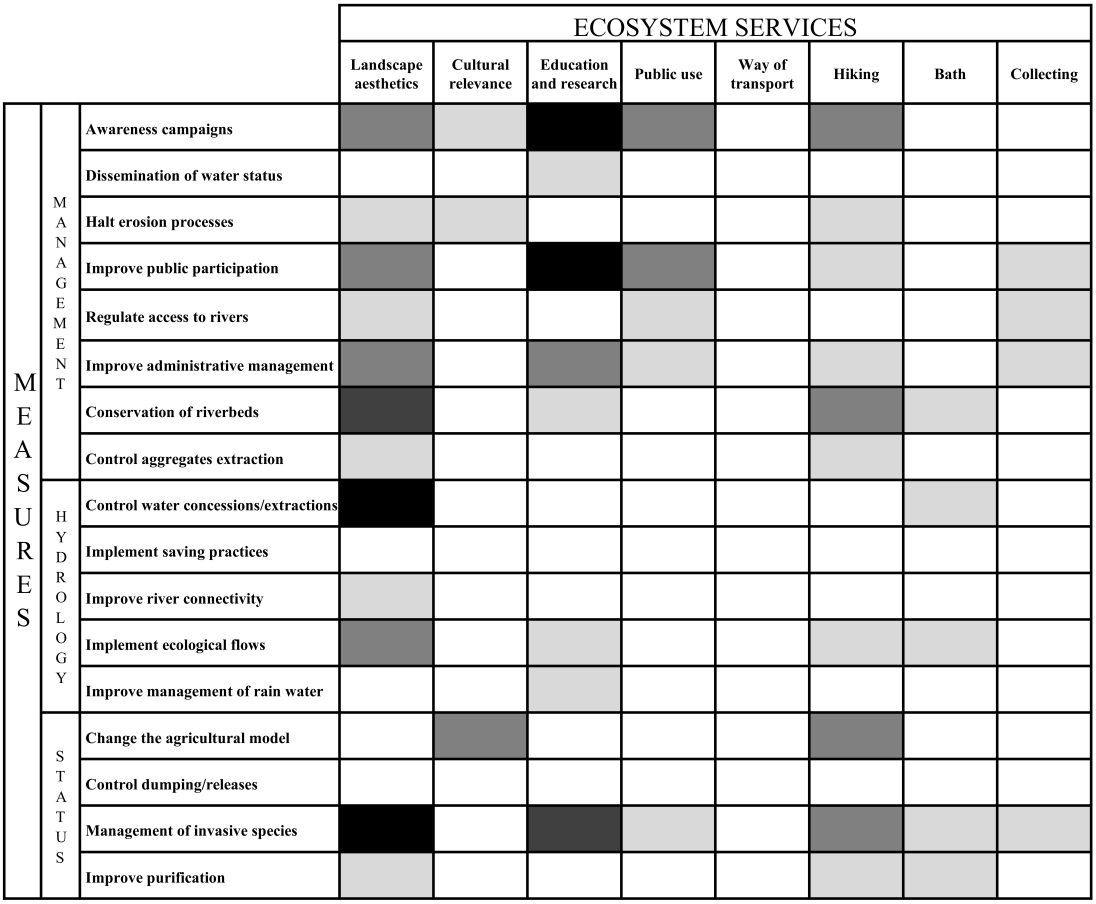


Figure 3. Cultural ecosystem services detected by face-to-face participants in workshops in relation to the proposed measures. Measures were divided by management, hydrology and ecological status of water body.



TABLES

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 *(Moellenka et al. 2010)*	Denmark *(Lieffrink et al. 2011)*	France *(Lieffrink et al. 2011)*	The Netherlands *(Lieffrink 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**	×	✓	×	×	✓	✓	×	✓	×	✓
	Collaborative	✓	×	✓	✓	×	×	×	×	✓	×
	Bottom-up initiative	×	×	×	×	×	×	✓	×	×	×
Type of stakeholders involved in the process	**Citizens**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Public administration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Research institutions	✓	×	✓	✓	×	×	✓	×	✓	×
	Private sector	✓	✓	✓	✓	×	✓	✓	×	×	×
Inclusion of stakeholders at early stages of the process		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Type of participatory engagement mechanisms	**Workshop**	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Interview	✓	✓	✓	×	na	naSI!!	✓	×	×	×
	Survey	✓	×	×	✓	na	na	×	×	×	✓
	Scientific dissemination	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Environmental education	×	×	✓	×	×	×	×	×	×	×
Evaluation items	**Satisfaction with the process**	✓	✓	✓	✓	×	✓	✓	✓	✓	×
	Real influence	×	×	×	×	×	✓	✓	✓	×	×
Inclusion of citizen science information		×	×	×	×	×	×	×	×	×	×
Inclusion of future global change scenarios		×	✓	✓	×	×	×	✓	×	×	×
Inclusion of ecosystem services		×	×	×	✓	×	×	×	×	×	×
Inclusion of temporary rivers		×	×	×	×	×	×	×	×	×	×

SUPPLEMENTARY MATERIAL

Figure S1. Distribution of the 22 water bodies grouped in 5 areas of participation which include several sites: Girona (A1; pink); East Tarragona (A2; purple); West Tarragona (A3; red); South Tarragona and Castelló (A4; blue), and Valencia (A5; yellow). Black sites were included in the LIFE+ TRivers project but not in the participatory process. A1 and A2 correspond to the Catalan River Basin District. A3 correspond to the Ebro River Basin. A4 and A5 correspond to the Júcar River Basin.

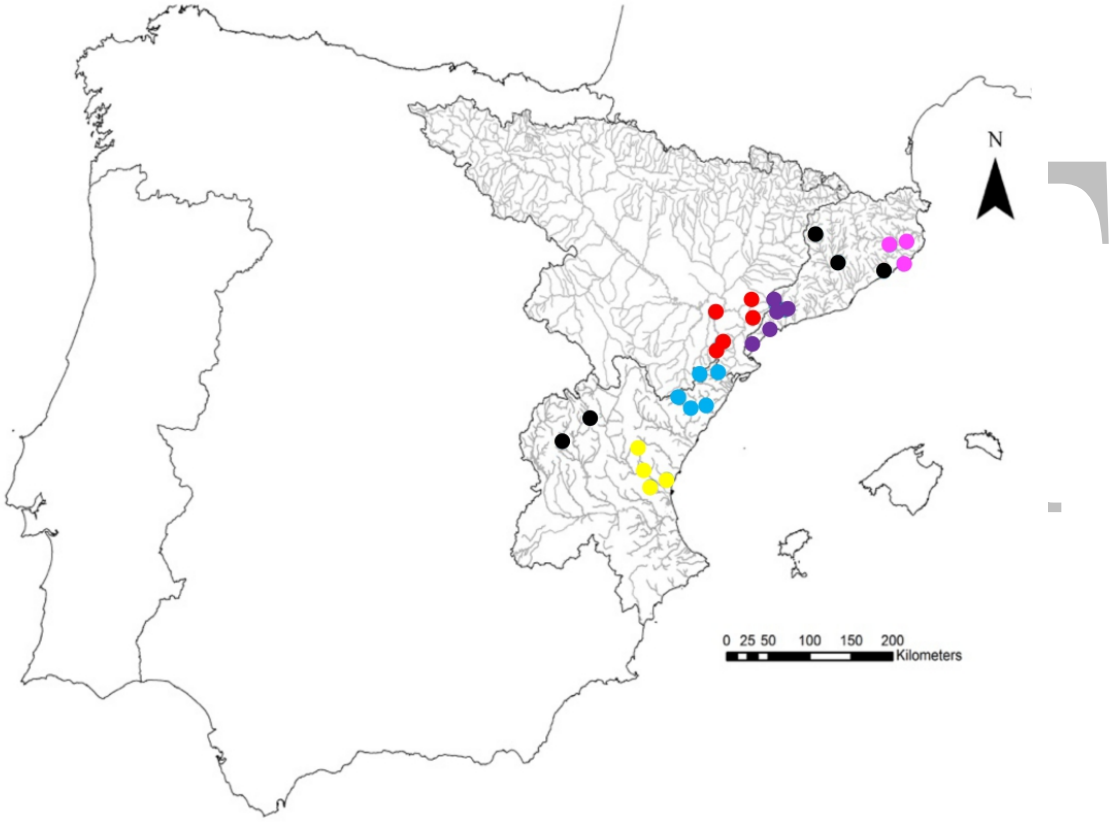


Figure S2. Pictures of our participatory process showing: (a,b) FEHM research group exposing the main topics; (c,d) dynamics to promote participants' contributions to the diagnosis of each water body; (e,f) field trip activity using the RiuNet app, and (g,h) prioritization dynamics conducted in the measures workshop.

Table S1. Summary of the face-to-face participants from both diagnosis and measures workshops.

	Specific sector	Name
CITIZENS	General public	General public
	Local environmental associations and non-governmental organizations	SITRA
		Salvem Gaià
		Associació medioambiental La Sénia
		Associació Hàbitats
		Plataforma pel riu Siurana
		Plataforma Sierra de Chiva
		AEMS ríos con vida
		Connecta Natura and Acció Ecologista-Agró
RESEARCH INSTITUTIONS	Universities	FEHM research group (University of Barcelona)
		UAB
	Institutes or entities	IDAEA-CSIC
		IRTA
		CIEF
	Private sector	Corriols i Riberes SL
		Crearqció and Fundación Natural Life
PUBLIC ADMINISTRATIONS	Water agencies	Catalan Water Agency
		Júcar River Basin District Water Agency
	Local municipalities	La Bisbal town council
		Alcover town council
		La Sénia town council
		Cheste town council
		Consorci de les Gavarres
		Parc Natural Tinença Benifassà

Table S2. Summary of the climate-related future impacts and measures identified by the participants from the face-to-face workshops. Status: ecological status. For further details, see the LIFE+ TRivers website (http://www.lifetrivers.eu/actions).

	Climate-related future impacts	Measures
MANAGEMENT	Lack of control of water concessions and increase of new ones	Social and institutional awareness campaigns
	Absence of awareness campaigns (social devaluation of river ecosystems)	Dissemination of aquifers and surface status
	An increase of erosion and sedimentation processes	Developing studies to halt erosion processes
	Lack of involvement of the competent administrations for the conservation of temporary rivers	Promote and improve public participation
	Prioritization of economic (e.g. tourism) vs environmental interests	Regulation of the access to temporary rivers
	A decrease of the riverine vegetation and/or its mismanagement	Improve administrative management (e.g. institutional coordination, competences to municipalities)
	An increase of the public use of rivers (e.g. bath)	Establish clear guidelines for the conservation of the riverbed and its riverside vegetation
	Modification of the WFD becoming less restrictive	Control and protocols/guidelines for aggregates extraction
HYDROLOGY	An increase of the dry period and temperature due to global change	Revision and control of water concessions and extractions
	An increase of aquifer exploitation	Implement saving practices
	Disappearance of other ecosystems linked to these rivers (e.g. lagoon)	Improve river connectivity (e.g. remove weirs)
		Implement (or accomplish) ecological flows
		Improve the management of rain water
STATUS	An increase of invasive species and genetic regression of species	Change the agricultural model (e.g. promote organic farming, increase fees for inappropriate agriculture)
	An increase of water contamination (e.g. by phytosanitary or illegal dumping)	Control of dumping/releases (fertilizers, livestock farms)
		Improve management of invasive species
		Improve purification (e.g modernization of collectors, wastewater treatment system in housing areas)

Table S3. Ecosystem services identified by face-to-face participants during the diagnosis workshop at the different areas of participation. See Figure S1 for the identification of the participation areas.

	A1	A2	A3	A4	A5
Landscape aesthetics	✓	✓	✓	✓	✓
Cultural relevance	✓		✓	✓	
Religion or spirituality					
Education and research	✓	✓	✓	✓	✓
Public use	✓	✓	✓	✓	
Way of transport					
Hiking	✓	✓	✓	✓	✓
Bath		✓	✓	✓	
Fishing and hunting			✓		
Collecting		✓	✓	✓	

Table S4. Examples of some of the most relevant measures that could be aligned with measures already included in the River Basin Management Plans (2016-2021) after the participatory process. Here only one measure from each participation area is shown. For identifying the participation areas (A1:A5) see Fig. S1. ACA: Catalan Water Agency (public water authority). CHJ: Júcar River Basin (public water authority). For further details, see the LIFE+ TRivers website (http://www.lifetrivers.eu/actions).

Area	Measure	Implementation and estimated cost in management plans 2016-2021
A1	**Eradicate invasive species.** General measure.	Twenty measures on this topic and a total 1,64M€ of investment within ACA.
A2	**Improve river connectivity.** General measure.	Several measures incorporated, including the need for building fluvial connectors in those structures impeding fish movement and migration or restore the river in case these strictures are not in use (measure nº A2.010). Related with these measures, three additional measures may contribute to the river connectivity: measure nº A2.007, dedicated to improve the information on fluvial connectivity, measure nº A2.006, to monitor actions, and measure nº A2.008 dedicated to dissemination of the activities. Costs associated to these measures are only included for measure nº A2.006 in the management plan 2016-2021, with a cost of €45,000.
A4	**Implementation of ecological flows (e- flows).**	Within the River Management Plan 2015-2021 there is the measure 08M1166 "Application of ecological flows in all water bodies of the CHJ". Several studies are planned for the Sénia river under the specific measure 08M1149 "Study of the relation river-groundwater and sub superficial fluxes in the river Sénia and implementation of e- flows". Only global budget provided by CHJ. 258,05 million euro to reduce water abstraction pressures. 6,20 million euro to reduce other hydrological pressures.
A5	**Improve wastewater treatment systems.** Improve the current treatment plant at Rambla del Poyo (Cheste- Chiva, El Oliveral).	Measure nº 08M0038. Basic actions in wastewater treatments in Cheste and Chiva. Only global budget provided by CHJ: 357,58 million euro for improving point-source pollution.

Table S5. Evaluation of the satisfaction (%) of the participatory process by face-to-face and online participants of both diagnosis and measures workshops. Ranging from very low to very high. For further details, see the LIFE+ TRivers website (http://www.lifetrivers.eu/actions).

Topics evaluated	Level of satisfaction (%)				
	Very low	Low	Indifferent	High	Very high
Place where the process was held (ubication, installations)	-	4	5	38	53
Dissemination activities announcing the process	-	10	7	33	50
Collaborative leadership (organization and logistics)	-	-	6	30	64
Time schedule and duration of activities (i.e. enough time for questions and meaningful discussion)	-	2	6	28	64
Achievable and clarity aims	-	-	6	46	48
Clarity of working papers	-	-	18	32	50
Participants' interest in attending	-	-	8	25	67
Improvement on the knowledge of rivers	-	5	5	40	50
Facilitation and working dynamics	-	-	-	24	76
Personal satisfaction in terms of real contributions in the diagnosis and measures stages	-	1	15	40	44
Participants involvement opportunities to freely bring their opinions	-	-	10	27	63
Diversity of stakeholders participating	-	5	17	37	41

Table S6. Results from online surveys conducted during the participatory process (% participants) showing the most common impacts identified in the water bodies, their climate-related future impacts and the management measures that could improve ecological status.

		Participants answers (%)
Most common pressures and impacts (diagnosis)	Uncontrolled dumping	13
	Insufficient sewage treatment	13
	Lack of information about temporary rivers	16
	Poor management of riverine vegetation	12
	Illegal water extractions	14
	Regulation infrastructures	12
	Invasive species	20
Climate-related future impacts (diagnosis)	Absence of awareness campaigns	19
	Increase of erosion and sedimentation processes	4
	Lack of involvement of the competent administrations	21
	Decrease of the riverine vegetation or its mismanagement	5
	Increase of the dry period and temperature	20
	Increase of aquifer exploitation	17
	Increase of invasive species	9
	Increase of water contamination	5
Measures	Social and institutional awareness campaigns	17
	Promote and improve public participation	16
	Conservation of the riverbed and its riverside vegetation	6
	Revision and control of water concessions and extractions	15
	Improve river connectivity	18
	Control of dumping/releases	9
	Improve management of invasive species	11
	Improve purification	8

Appendix A1. Methodologies about the selections of the studies from Table 1

We identified only published studies from an ISI Web of Knowledge (<www.accesowok.fecyt.es/>) literature search that recorded participatory processes under the WFD context and that were related to the development of the river basin management plan (RBMPs) and the proposal of measures (PoMs) (i.e. not only to specific measures). Member states were required to have produced the first RBMPs and PoMs by 2009 (EC, 2009) and, thus, we considered a time span from the 2003s (i.e. 2003-2009 six-year cycle) to the 8th of March 2020. A comprehensive search string of multiple terms for participatory process has been used, which resulted in 23 records. These 23 studies were from 12 different countries and different river basins: Ribble, Ythan, Dearne, Derwent, Dee, Belfast Lough and Lagan (United Kingdom), Rhone (Switzerland), Muga, Guadiana, Ebro, Western Costa del Sol, Miera and Campiazo (Spain), Meuse (The Netherlands), Flemish (Belgium), Dordogne and several other river basins (France), Danube (Hungary), Bacchiglione (Italy), Guadiana and Alentejo region (Portugal), Evinos and Naxos (Greece), Dhuenn and Elbe-Lübeck (Germany) and several river basins from Denmark. We manually re-screened each of the 23 publications to select those relevant for our study according to the following criteria: the publication had to discuss or provide direct insights into the leadership of participatory process, the potential groups (i.e. stakeholders) that could be engage in a participatory process, which types of mechanisms were used to their engagement, which type of rivers were included (i.e. perennial or temporal rivers) and whether they included citizen science information, future scenarios and the concept of ecosystem services. This selection resulted in a total of 5 publications including 10 study cases.

Appendix S2. Further details on the type of stakeholders, leadership and dissemination activities of our study case

There was a collaborative leadership between the two water management authorities (i.e. Catalan River Basin District and Júcar River Basin District), two research institutions (i.e. the University of Barcelona and the IDAEA-CSIC, with members belonging to the FEHM research group; www.ub.edu/fem), and one professional independent mediator with experience in participatory processes. The two water management authorities and the two research institutions were partners of the LIFE+ TRivers project.

Dissemination activities announcing the process were developed through the TRivers website (www.lifetrivers.eu/actions) social networks (i.e. Twitter and Facebook) and eBando (i.e. mobile application that share local events and announcements in municipalities). Besides, preliminary scientific dissemination on the diagnosis of each target water body was conducted one month before the start of the workshops (Fig. 1b). Information panels and leaflets were placed in strategic buildings of municipalities (e.g. city halls) and protected areas (e.g. natural park offices) close to the sampled water bodies during the project. Once stakeholders were identified, they were also contacted by e-mailing and ®WhatsApp. To facilitate the participation of stakeholders, both diagnosis and measures workshops were held in the most central village in each of the 5 area groups (Fig. S1). Participatory workshops took place between October and December of 2017, and the duration of each workshop was about 3-4 hours.