A pan-European survey to strengthen and improve policies and strategic planning regarding river continuity restoration

The network for best practices of river restoration in Greater Europe

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A pan-European survey to strengthen and improve policies and strategic planning regarding river continuity restoration

S. (Sharelle) Verheij, B. (Bart) Fokkens & A.D. (Tom) Buijse

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Rationale

From July 2020 up to and including January 2021, the River Continuity Survey commissioned by the European Centre for River Restoration (ECRR) and carried out by the Dutch Foundation for Applied Water Research (STOWA) has been set-up, distributed, and its answers have been translated into results, conclusions and recommendations. This project is fulfilled by Sharelle Verheij, an Aquaculture and Marine Resource Management master graduate at the Wageningen University and has been guided by the project group: Bart Fokkens (ECRR), Bas van der Wal (STOWA), Martijn van Staveren (Wageningen University and Research) and Tom Buijse (Deltares). The goal of the survey was to obtain a pan-European overview of the current policies and future plans regarding river continuity in all countries of pan-Europe.

Undisturbed river continuity - free-flowing and without artificial barriers - is fundamental to the hydromorphological and ecological health of rivers. Recent studies and inventories indicate that the degree of river fragmentation by artificial barriers is remarkably high in many regions and countries of greater Europe and river restoration is considered the most progressive mechanism to improve this. Therefore, the ECRR has decided to raise awareness, disseminate information and develop knowledge and practices to support river continuity restoration. Across the ECRR member countries it was commonly agreed that there is currently no overview on the longitudinal river continuity restoration policy, planning and implementation status of the various countries. Therefore, this project is set up to investigate the situation in each country and to ask the national river management authorities to clarify the general and country specific policies, demands and the support that is needed. European and national governments, supported by NGOs and (knowledge) networks (such as the ECRR), can together contribute to developing the policy, planning and implementation to achieve the specific goal of longitudinal river continuity restoration.

A river continuity survey approach made it possible to investigate the current situation regarding the recognition of the importance of river continuity in national policies and the potential for restoring river continuity. By getting to know the country specific situations, the questions have provided insight into policies and the required support concerning guidance and tools. In order to advance river continuity restoration, what should be the main strategy per country and/or group of countries? This has been analysed through 60 questions, put to national governments which covered the following topics:

1. *Recognition of river continuity in current national policies*
2. *The potential of river continuity restoration in your country*
3. *Observations/opinions on the importance of and opposition to river continuity restoration*

The answers to this survey and the results of their analyses have allowed initial conclusions and recommendations to be drawn as to the current situation regarding river continuity restoration policies and strategic planning in wider Europe. This information can be used in follow-up activities to formulate advices, improve current policies or propose and develop new policies and national restoration strategies, and generate greater support. Altogether, this could subsequently be developed into a Europe-wide openly accessible database on the plans, progress and status of river continuity, assisting national governments and river authorities in restoring river continuity. This will be beneficial for all the participating countries for achieving water legislation targets to improve the ecological status and UN Sustainable Development Goals.

1 Introduction

This river continuity survey was performed by the Dutch Foundation for Applied Water Research (STOWA) as commissioned by the European Centre for River Restoration (ECRR). STOWA is a knowledge centre of the regional water managers in the Netherlands - the Dutch Water Authorities. STOWA develops, gathers, distributes and implements applied knowledge that water managers need to properly carry out their profession. The ECRR is an association forming a European collaboration network that encourages and supports best practices in ecological river restoration. They do so by collecting and disseminating information on the ecological restoration of rivers and their floodplains across Europe, which influences decision making and the perspectives of researchers, NGOs, practitioners and policymakers. They support the implementation of the EU Water Framework Directive, Flood Directive, UN Sustainable Development Goals, UNECE Water Convention, the Convention on Biodiversity, as well as national policies. Moreover, the ECRR has for a number of years river continuity restoration strategically chosen as a guiding theme for its promotion plans and supporting activities. Besides the executive foundation and the commissioner, Deltares has given advice regarding the project. This independent institute for applied research in the field of water and subsurface frequently focuses on deltas, coastal regions, and river areas, often in collaboration with governments, companies, knowledge institutions and universities.

The project embraced setting up a pan-European survey to investigate the current situation regarding the policies and planning of river continuity restoration in the Greater Europe. With this survey the aim was to create an overview on the status and potential of longitudinal river continuity restoration within Europe. As the ECRR has acknowledged, there has not been a similar overview yet, which can make this report and the results from the survey of great meaning for future improvement of the ecological status of rivers. Ultimately, this can be beneficial for all the participating countries for achieving the relevant water legislation targets and UN Sustainable Development Goals.

BACKGROUND INFORMATION

Rivers are beneficial to society by the biodiversity and ecosystem goods and services that they provide. They enable us to drink clean water, harvest plants and animals, travel and transport, remove waste and generate renewable energy (Allan & Flecker, 1993; Postel & Richter, 2003). Besides, the mitigation of floods and droughts, maintenance of food webs, and delivery of nutrients and sediments to coastal estuaries are some of the ecosystem services that rivers provide (Postel & Richter, 2003). There are so many more recreational, aesthetic, cultural, and spiritual (in) direct benefits from rivers that are hard to express monetarily. Nevertheless, the economic value of rivers has been estimated by a team of ecologists and economists in the mid-nineties. They estimated rivers and lakes together to be worth $8,500 (or more than €7,000) per hectare per year, mostly due to the regulation of the hydrological cycle and the provision of water supplies (Costanza *et al.*, 1997). This shows that rivers are much more valuable than can be seen from their direct revenue and they should be protected from factors that affect their goods and services.

River barriers and their effects

Dam construction is often mentioned in scientific studies as one of the factors that threaten the values provided by rivers (Brevé, Buijse, Kroes, Wanningen & Vriese, 2014; Drouineau *et al.*, 2018; Kemp & O'Hanley, 2010; O'Hanley, Wright, Diebel, Fedora & Soucy, 2013; Postel & Richter, 2003; Segurado, Branco & Ferreira, 2013). River barriers, including dams, weirs, culverts, fords, sluices, and ramps or bed sills, are man-made obstacles that are installed in rivers for specific, mostly provisional, ecosystem services such as flow regulation, hydropower generation, water level control or erosion reduction (AMBER, 2020). Other functions include transport (navigation), recreation, water storage for agriculture (irrigation) and drinking water, flood protection, and cultural heritage. However, they obstruct a river, disrupting the longitudinal flow of the water, sediment and aquatic biota, preventing the existence of river continuity. Only free flowing, unfragmented rivers in both longitudinal and lateral direction without natural or artificial barriers can provide the before mentioned values to their completeness and integrity.

The many placements of man-made barriers in rivers worldwide in the twentieth century have disconnected the upstream freshwater habitats from the oceanic habitats (Dynesius & Nilsson, 1994). Damming or obstructing a river

can vastly alter some ecosystem properties: water depth, flow regimes, channel morphology, sediment loads, chemical properties, and thermal conditions (Baxter, 1977; Ward & Stanford, 1987). The disruption of river continuity has been shown to result in a major decrease in species diversity (Joy & Death, 2001; Morita & Yamamoto, 2002), as well as population declines and even extirpation of freshwater fishes and mammals (Allan & Flecker, 1993; Miller, Williams & Williams, 1989; Page, Pyron & Cummings, 1997). Multiple studies comparing pre- and post-impounded systems have found substantial reductions in the number of species within these systems across the basin (Eley, Randolph & Carroll, 1981; Kapasa & Cowx, 1991; O'Hanley, Pompeu, Louzada, Zambaldi & Kemp, 2020).

Migratory fish and other aquatic fauna can often not pass river barriers and are thus confined to the parts of the river that are situated in between the barriers. This obstruction of migration routes of migratory fish species and other aquatic organisms such as shellfishes and crustaceans, is known as the 'barrier effect' (Morita & Yamamoto, 2002). Salmonids and anguillids have a great cultural and economic value, with the latter being of great importance due to the high market value of glass eels (Drouineau *et al.*, 2018). However, due to barriers in the rivers, the populations of these fish species have declined, and so their economic revenue (Kruse & Scholz, 2006; Quigley & O'Brien, 1996; Wolter, 2015). Barriers result in adult fish being faced with the problem how to circumvent the barriers in order to reach their spawning grounds and direct mortality can be the result of turbines in a barrier (Drouineau *et al.*, 2018). Besides the adults, the young fish are affected by the turbines pressures and weakened by the higher swimming effort that is necessary due to the lower currents (Allan & Flecker, 1993). On top of that, many indirect impacts by barriers are mentioned by Drouineau *et al.* (2018), such as over-predation, overfishing, stress, diseases, and selective pressure. The Living Planet Index reports that the global migratory freshwater fish populations have declined by 76%, and in Europe only there has been a decline of 93% over the past five decades (Deinet *et al.*, 2020). Though, migratory fish are important for ecosystems, because they transport nutrients from oceans and provide food for terrestrial animals; they are a food security and livelihood for millions of people; and recreational fishing is worth billions in dollars or euros every year (Carrington, 2020). Something must change in order to bring back the migratory freshwater fish.

River continuity restoration

Only 37% of rivers around the world that are longer than 1,000 kilometers are still free flowing and only 23% flow into the ocean without interruptions (Grill *et al.*, 2019), so the current status of global river continuity is not good and it is worsening. Equipping river barriers with efficient fish passes, such as fish ladders or lifts, and installing by-pass systems improves connectivity mainly for fish, whilst removing the barrier completely would restore the river continuity entirely. River continuity restoration will help to prevent the extinction of diadromous fish species and to achieve the relevant water legislation targets and UN Sustainable Development Goals. But we already know this for quite some time. We know how to restore the river continuity on paper, but how do we get there in practice? How do we incentivize policymakers and stakeholders to change their way of operating and accept sustainable alterations as the new norm? To answer this, we first must know the current situation in different countries. National legislations can differ among countries, even within a collaboration overarching various countries, such as the European Union. We must first recognize what is currently done in order to improve the activities around, and above all, the way of thinking about river continuity. Restoring river continuity in a large group of countries requires an in-depth research into the various policies, plans, strategies and potential of legislations and financial situations of the comprising individual countries.

UN Decade on Ecosystem Restoration

The ECRR is a supporting partner of the UN Decade on Ecosystem Restoration and wants to use the movement to promote its plan and supporting activities, especially concerning the longitudinal hydro-morphological continuity. The ECRR is concerned as it has not been viewed as a significant issue thus far. The ECRR's view is that whilst there is a considerable body of evidence and a range of benefits, there is in most countries still no integrated programmed approach to river continuity restoration. However, there are many ongoing and finished projects concerning restoration of river continuity, but the (best) practices part of river continuity restoration and the dissemination of such restoration measures is still underexposed. Therefore, the ECRR has chosen river continuity restoration as a guiding theme for its promotion plans and supporting activities as part of the support to the UN Ecological Restoration Decade movement.

2 National policies and strategies recognizing river continuity

EU WATER FRAMEWORK DIRECTIVE & RIVER BASIN MANAGEMENT PLANS

For EU member states the Water Framework Directive (WFD) is an essential driver to restore river continuity. It is an EU water legislation which commits European Union member states to achieve qualitatively and quantitatively good ecological and chemical status (GES) of all water bodies in the EU, or good ecological potential (GEP) for heavily modified or artificial water bodies. The ecological and chemical status of water bodies are assessed according to their biological, hydromorphological, and (physical-)chemical quality. Undisturbed river continuity is an important hydromorphological element that determines the ecological status or potential of a river (Mader & Maier, 2008). The WFD also states that because some river basin districts exceed national borders, management based on the natural geographical and hydrological unit (river basin) is essential instead of looking at the administrative and political boundaries (European Commission, 2020a). Therefore, each river basin district needs to have a River Basin Management Plan (RBMP) for every six years. They are a means of achieving the protection, improvement and sustainable use of the water environment across Europe. The WFD was adopted on the 23rd of October 2000 and came to force on the 22nd of December in that same year (European Commission, 2020a). Although the original plan aimed to achieve the goals by 2015, the goals remain unchanged in the present.

UNECE WATER CONVENTION & SUSTAINABLE DEVELOPMENT GOALS

Besides the WFD for EU member states, any UN member state can ratify the United Nations Economic Commission for Europe (UNECE) Water Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE, 1992). This is an international legal instrument and intergovernmental platform which aims to ensure the sustainable use of transboundary water resources by facilitating cooperation between parties that border the same waters (UNECE, 2020). The Water Convention works towards achieving the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development (UNECE, 2020). The Agenda commits to a worldwide elimination of poverty and achievement of sustainable development by 2030 by - among other things - directly supporting the implementation of target 6.5 which requests all countries to implement integrated water resource management with appropriate transboundary collaborations. The adoption of the 2030 Agenda was a milestone providing a shared global vision of sustainable development for all (European Commission, 2020b).

UNECE AARHUS CONVENTION & MAASTRICHT RECOMMENDATIONS

Besides the Water Convection, The UNECE Aarhus Convention - or the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters - has been crafted. Developed under this treaty are the 'Maastricht Recommendations on Promoting Effective Public Participation in Decision-making in Environmental Matters prepared under the Aarhus Convention'. This global legally binding instrument covers public involvement to be implemented in decision making processes of negotiation and implementation of international agreements (UNECE, 2015).

EU BIODIVERSITY STRATEGY 2030

The EU Biodiversity Strategy for 2030 has been published on the 20th of May, 2020. It is a long-term plan that will be used to protect nature and change the course of ecosystem deterioration by recovering Europe's biodiversity. Since the Biodiversity Strategy has been accepted so recently, it already includes plans for the international negotiations regarding the global post-2020 biodiversity framework in the post-pandemic context. It aims to improve the resilience of the society to future threats that we see today: climate change impacts, forest fires, food insecurity and disease outbreaks (European Commission, 2020c; European Commission, 2020d). One of the goals that the Biodiversity Strategy commits to is restoring 25,000 kilometres of rivers to be free-flowing rivers by 2030 (European Commission, 2020c). This is planned to be done primarily by removing obsolete barriers and restoring floodplains and wetlands.

NATURA2000

Natura2000 is the largest coordinated network of protected areas around the world, stretching over 18% of the land in the 27 countries of the European Union and 8% of their marine area (European Commission, 2020e). Europe's most valuable and threatened species and habitats (listed under the Birds Directive and the Habitats Directive) are protected with this network, ensuring their long-term survival (European Commission, 2020e). The Member States are required to protect the designated sites and ensure that they are managed ecologically and economically sustainable. Some free-flowing river stretches, but also some wetlands and lakes resulting from dam constructions are classified by Natura2000, due to their value for birds or other animals or plants (Drouineau *et al.*, 2018).

POLLUTER PAYS PRINCIPLE

The Polluter Pays Principle (PPP) is, in first instance, a chemical principal that is used for allocating the deterioration costs of environmental resources, meaning the polluter will bear the expenses of the goods and services that cause pollution in production and/or consumption (European Commission, 2020f; OECD, 1972). This will reflect the relative scarcity of the environmental resources to a higher standard, which will economically drive the regarding entities to prevent pollution and control measures.

These are some of the policies and instruments that are currently regulated as official legislations and plans towards a better future. For all of the beforementioned policies and strategies, restoring the continuity of rivers is one of the measures that can and should be implemented to work towards achieving these goals and targets. Besides these legally binding tools, there are also other pressures that can drive barrier owners to remove or adapt the river barriers in such a way that the rivers original goods and services can still be provided. Whenever a barrier is obsolete, so its practical use is not necessary anymore, the barrier can most likely be removed. Once such an arising opportunity is noticed, the particular barrier owner can be pressured into removing the barrier or they can receive money from an authority that can remove the structure. However, for some barriers the utility is still profitable. To decide which barriers can be considered obsolete and which are still useful, it is important to know what the various functions are of river barriers, and how these functions are regulated.

3 Barrier functions and regulation

HYDROPOWER GENERATION

The generation of hydropower - or hydroelectric power - is one of the reasons why barriers (in this case dams) are built and put to practice in initially free-flowing rivers, hindering the river continuity. Hydropower is considered by many a clean and renewable energy source, making is better for the environment than fossil fuels or nuclear power. It is generated through the hydraulic forces of water through turbines, while the dam provides water storage reservoirs to adjust the flow to match the power demand (Bakis, 2007; Renöfält, Jansson & Nilsson, 2010). The demand of hydropower will presumably increase, with the use of fossil fuels being reduced. However, the production of hydropower substantially transforms the rivers and their ecosystems which is not desirable, and the increasing demand will then increase the pressure on freshwater ecosystems even more. There is a trade-off between a secure energy supply, reducing climate change, and improving water quality (Abazaj, Moen & Ruud, 2016).

INLAND TRANSPORT OVER WATER (NAVIGATION)

So-called navigation dams are designed to keep water levels sufficiently high to enable navigation, so instead of flood control purposes, they ensure a permanent coverage of river reaches (EEA, 2020). All transport in Europe is for almost 6% accounted for by the inland waterways, mainly over the Rhine and Danube (Tournaye, Pauli, Saha & Van der Werf, 2010). Inland water transport requires the right infrastructure to have a sufficient number of pathways available. This requires rivers to be interconnected and technical features such as width and depth to be similar among the various river basins, so vessels can easily operate on them (Tournaye *et al.*, 2010). Certain river barriers and the re-infrastructuring of river basins to reduce the degree of fragmentation could be implemented to create such a network of inland waterways for transport (Sys, Van de Voorde, Vanelslander & Van Hassel, 2020).

CULTURAL HERITAGE

A cultural heritage is defined as a tangible (monument, site, art piece) or intangible (tradition, ritual, expression, knowledge, skill) resource that is inherited from the past and creates modern societal, environmental and economic benefits (UNESCO, 2017). Cultural heritages can create a form of cultural identity, sense of belonging, and community inclusion, which provides psycho-social support and enlarges community resilience against environmental and socio-economic stresses (Fatorić & Biesbroek, 2020). UNESCO ensures cultural heritages to be preserved by regulations, partially contributing to the achievement of the SDGs of the Agenda 2030. Some river barriers are known to be listed as UNESCO World Heritage Site, such as the dams in the archaeological ensemble of Mérida in Spain that still have their original function (UNESCO, 2020a). In fact, the origin of the international convention of UNESCO and its legally protected areas derives from the initial protection of an Egyptian dam - the Aswan High Dam - that was appealed by the government to be legally protected in 1959 (UNESCO, 2020b). This led to the recording and recovery of hundreds of sites and thousands of objects by UNESCO and the International Council on Monuments and Sites (ICOMOS) in an International Campaign lasting from 1960 to 1980. This could make the removal of a barrier difficult as it might oppose the cultural-historic values, recreational opportunities or aesthetical landscapes (Born *et al.*, 1998; Brummer, Rodríguez-Labajos, Nguyen & Jorda-Capdevila, 2017; Lejon, Renöfält & Nilsson, 2009).

RECREATION

Although free-flowing rivers provide recreation through for instance river fishing, tubing, canoeing and other paddle sports, dams can also bring recreational value through the impoundment leading to the creation of new waterscapes (Born *et al.*, 1998). In these newly formed reservoirs recreational activities can be practiced such as sailing, swimming and sport-fishing. A study by Hoenke, Kumar & Batt (2014) found that 64% of the 5,120 dams they researched had recreation as their primary function. However, recreation is not considered an important so-

cial use or actual functional use of dams (Hoenke *et al.*, 2014), since you can also create recreation with other means than a river barrier. In terms of barrier functions, it belongs to the secondary functions that artificial river barriers offer.

WATER STORAGE FOR AGRICULTURE (IRRIGATION) AND DRINKING WATER

Water reservoirs that are created by the placement of dams can be used to answer to the need to supply water in the right quantity and quality at the right time and place, the reallocation of water, and using surface water and groundwater resources together (Altinbilek, 2002). One of the barrier functions that contribute to this is irrigation, where the land receives more water than would normally be the case (Mayordomo, Antequera & Hermosilla, 2018). This is subsequently used by agricultural practices to produce food for human consumption. It is estimated that dams contribute to 12 to 16% of the world's food production through irrigation, making around 1 billion people dependent on reservoir-related irrigation (Altinbilek, 2002). Besides irrigation, public water supply can be provided by the water reservoirs yielded by dams. In the Netherlands almost a third of all drinking water that is produced comes from surface waters, mainly from the Meuse and Rhine rivers (Van Breemen, Ketelaars, Hoogenboezem & Medema, 1998).

FLOOD PROTECTION

Dams can alter the seasonal cycles of floods, reducing the discharge of flood water during peaks (Agostinho, Pelicice & Gomes, 2008). For the duration of such an excess flow of water, dams can ensure water storage in the reservoir and release when natural flows are insufficient for the natural services of river flows (Altinbilek, 2002). Controlling this discharge volume has been proven effective in the protection against floods (Hayashi, Murakami, Xu & Watanabe, 2008). This can thus be used as a measure to achieve the EU Floods Directive goal of assessing and managing flood risks.

All these functional uses are regulated with permits (various kinds of rights) or by law (Arcadis, 2011; Glachant, Saguan, Rious & Douguet, 2014). The permits can differ per function, but also within the same function various permits can be applicable, depending on the structure. Permits can be valid for a short period of time after granting (0-25 years), moderately long (25-50 year), very long (50-100 years) or unlimited (100+ years) (Glachant *et al.*, 2014). Besides, there are cases where the function is not regulated by a permit or law at all. This can vary per country under different national policies, as well as the legal obligations to remove barriers after the duration of their permit validity. This is a factor in the decision-making process on which barriers to prioritize for measures to improve or restore the continuity of rivers.

4 Restoration measures to improve continuity

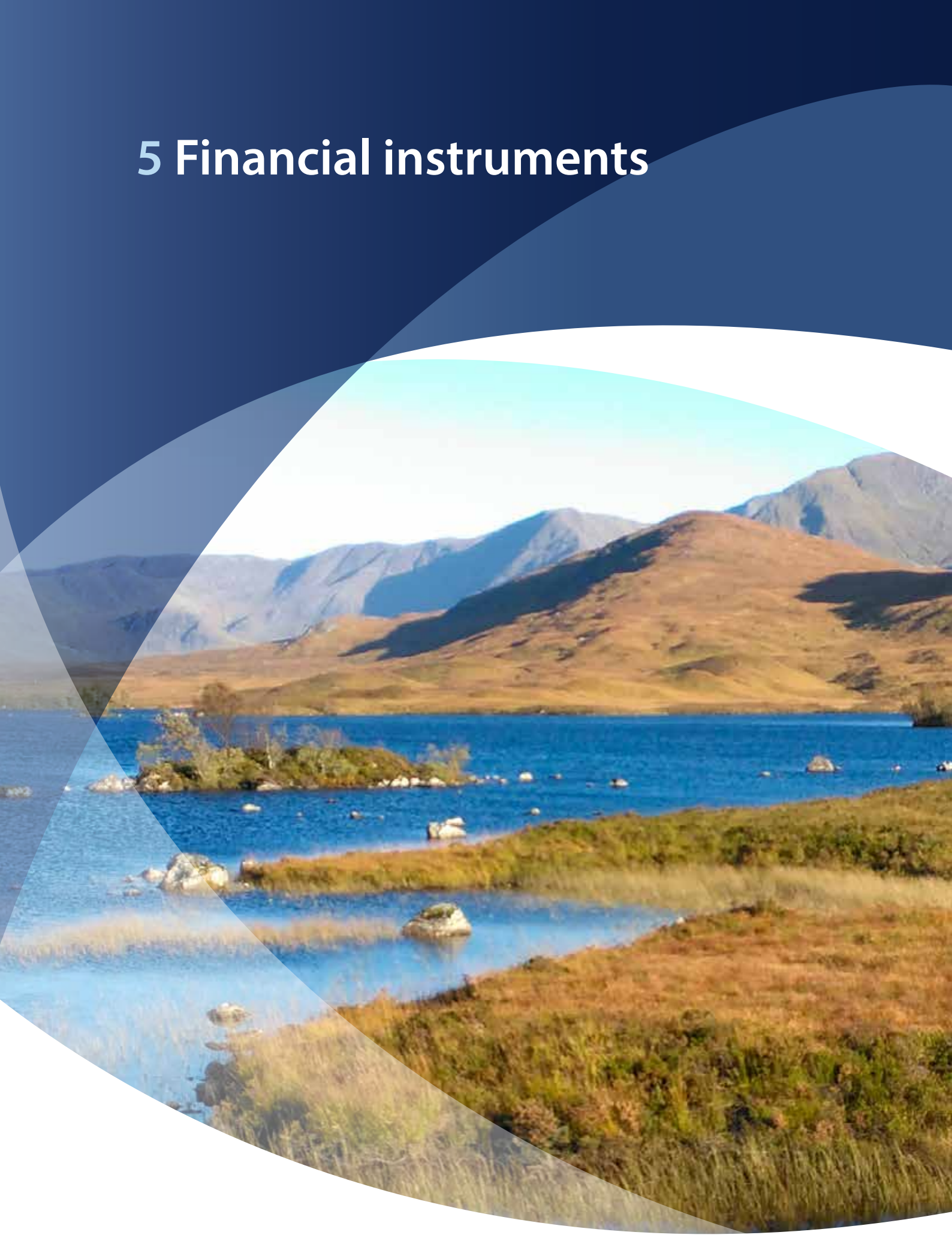
To shortly summarize, barriers are used for hydropower generation, transport via inland waterways, recreation, water storage for agriculture and drinking water, and flood protection and they can be considered cultural heritage. These functions are beneficial but can be questionable to some by also resulting in ecologically detrimental outcomes. All effects should be considered when prioritizing existing barriers to include measures, such as complete removal or adding a fish pass.

Hoenke *et al.* (2014) came up with multiple barrier prioritization tools that can be used to determine which potential dam removal projects to implement prior to others. One of their conclusions was to remove those that are primarily used for recreational purposes, since this is not an initially intended functional use of a river barrier. Besides, these dams are located more upstream of a river, meaning their removal can have positive effects on many kilometres downstream of the river, and these upstream areas are usually of high habitat quality. Poff and Hart (2002) describe how the various sizes, operational modes, and ages of dams, as well as the number of barriers per river basin affect the potential to restore the rivers through the removal of the barriers. The characteristic that seemed most prevalent in the ability to remove a dam turned out to be its size. This is due to the facts that there are more small barriers than for instance high dams, these small barriers do not provide the major services that large barriers do (hydroelectricity generation and/or flood control), and there is a lower economic benefit in maintaining them compared to the high dams. Public safety even seems to be jeopardized by small barriers due to their old age, and the costs of repair are very high compared to removal (Born *et al.*, 1998). Apparently, the 'low hanging fruits' in terms of achievable dam removal plans are the small barriers (small size and old age) and those that currently only remain intact for the purpose of recreation. Additionally, obsolete structures that - besides having lost their initial function - do not even have a recreational purpose anymore can most of the times easily be removed.

Another action that can be taken to improve the river continuity is the addition of a fish passage through or around existing barriers. Fish ladders and lifts allow large fish species to position themselves upstream alongside or through a barrier (Agostinho *et al.*, 2008). Other options that facilitate upstream fish passage are Denil fish passes, pool fish passes, or pre-barrages (Larinier, 2008). Lastly, natural bypass channels can be used so that the barrier and its function can continue to operate, while the problem for migratory fish is partially diminished (Larinier, 2008). Increasing the number of barriers that are provided with an efficiently operative fish passage could, by restoring the habitat connectivity, take away a lot of the ecological damages that are done by the artificial river barriers that have the largest environmental or ecological impact. However, it does not completely restore the river continuity.

Lastly, dams could be modified in such a way that the amount of water that is released at a certain speed creates a water and sediment flow that is closer to the natural situation, and the water quality of downstream water could be improved by aeration and altering the temperature (Hart *et al.*, 2002). Fully effective river (continuity) restoration and thus watershed management should be approached by determining which of the environmental and socioeconomic consequences of on the one hand keeping a dam in place and on the other hand the removal of an artificial river barrier outweigh the other. Of course, the financial situation also plays a big part in the choice of which measures to implement. The available finances could determine if any investment into the implementation of measures is possible. Since the majority of the dams, at least in the US, are privately owned (Evans, Mackey, Gottgens & Gill, 2000; Lieb, Casey & Minkoff, 2019), a potential financial problem could be narrowed down if for instance a governmental entity was to purchase the owner rights of the structure to thereafter cover the costs of its removal, reparation, or structural improvement.

5 Financial instruments



In the EU many financial instruments are available to monetarily support the realization of river barrier modifications among many other improvements. From whom these finances are originating, as well as to whom they are provided depends on the scale of the fund. With an increasing scale size, financial resources can be either private, regional/provincial/local governmental, national governmental, national, European (Union) or global. Private funds are founded by philanthropic resources or fundraising activities by e.g. NGOs, whereas the other scales indicate municipal, governmental, or ministerial resources (Del Tánago, De Jalón & Román, 2012).

An example of a European Union financial instrument is the LIFE programme, which is managed by the European Commission. The LIFE programme started in 1992 and has since financed around 4,000 projects across the EU with a total of 3.1 billion euros (European Commission, 2020g). Another EU fund is the European Maritime and Fisheries Fund (EMFF), which is one of the five European Structural and Investment Funds. For 2014 up until 2020 6.4 billion euros has been made available on behalf of this fund to implement the Integrated Maritime and Common Fisheries policies (European Commission, 2020h). Yet another fund that is made available for the years 2014 to 2020 is the fund from the largest EU Research and Innovation programme so far, Horizon 2020. For these seven years almost 80 billion euros have been provided to work towards the aims of the Innovation Union through numerous projects (European Commission, 2020i). Other examples of financial sources that can provide better water management are water funds such as the Water Sector Fund (WSF) with support from the Dutch government of 3.3 million euros (EIB, 2020). Lastly, lottery funds, relevant grants, sponsor packages, or crowdfunding campaigns are every so often used to assist in restoring river continuity.

Economic and financial instruments together form one of the three categories of policy instruments for implementing nature-based solutions, with the other ones being regulations, and information and education (Bhardwaj, Gupta, Dhyani & Thummarukudy, 2020). The economic and financial instruments can drive stakeholders to diminish the negative effects that they have on ecosystems and/or the environment by aiding in financing alternatives (Bhardwaj *et al.*, 2020). In terms of river continuity restoration, stakeholders can be financially incentivized (directly or indirectly) or granted with a certain amount of money to achieve the policy goal of increasing the longitudinal and lateral continuity of rivers. Such a financial incentive will greatly take away any unwillingness to participate, though the various groups of stakeholders still have to be on the same page about the steps that need to be taken.

6 Stakeholder groups and perspectives

Stakeholders should share knowledge, risks and rewards in the management of a common property (Rogers, 2006) - in this case water. As Petursdottir, Arnalds, Baker, Montanarella & Aradóttir (2013) have concluded: social factors such as the attitude and behaviour of stakeholders determine the level of effectiveness of restoration policies. Environmental issues are usually a concern for situational experts and scientists that work for governmental or non-governmental organizations, and environmental activists (McBeth, Lybecker & Stoutenborough, 2016). In a partnership together with the society and management agencies a decision-making process towards better management of rivers is led by these stakeholders.

A stakeholder is defined by Freeman in 1984 as "*any group or individual who can affect or is affected by the achievement of the firm's* (organization's) *objectives*". This suggests that besides scientists, society, and management agencies there are several groups of stakeholders that can be identified in the environmental issues regarding river continuity. Weng (2005) mentions the government, general public, NGOs, industrialists, and farmers as the main stakeholders in river management with others being entrepreneurs, communities, educational institutions, fishermen, conservationists, tourists and so on.

STAKEHOLDERS SUPPORTING RIVER CONTINUITY RESTORATION

The stakeholders who are likely to have a positive effect on the realization of river continuity restoration are governmental organizations, environmental non-governmental organizations (NGOs), as well as fishery organizations and the recreational sector (i.e. angling fishermen).

Governmental organizations

Governments can enforce legislations and regulations affecting all stakeholders, increase the integration of policies and directives, raise awareness among the public sector and increase political attention. Public participation (e.g. collaborative planning), demonstration of best practices, and making use of citizen science can promote and advertise the problems and their potential solutions among the various stakeholder groups. Awareness raising is an important means to achieve a higher general understanding of current affairs.

Non-Governmental Organizations

NGOs, who have become more and more influential in world affairs and are consulted on governmental and international level by various organizations, majorly effect the social, political and economic life of their target population (Neba, 2009). They can do this by lobbying, advocacy, campaigning, education and training. This is where awareness raising again is realized among both the public as well as in politics. Natural scientists and technician experts (engineers) in river management working for NGOs can amplify the influence of NGOs on the government to implement policies on river continuity restoration. NGOs can disseminate the knowledge they have gained and indirectly influence the policies by informing the public who ultimately bases its governmental voting decisions on this knowledge.

Fishermen

The last category of stakeholders that can and do have a positive effect on river continuity restoration are the fishermen. In Europe most of the fishermen fish for recreational reasons or to enjoy nature's aesthetics, as opposed to gaining food which is the most important factor for the fishermen in Africa and Asia (Unfer & Pinter, 2018). The recreational form of fishing is of great economic, social and ethical value. Unfer and Pinter (2018) even stated that anglers form the most prominent stakeholder group in restoring freshwater ecosystems, due to their experience and knowledge from the close tie to aquatic ecosystems. Since fishermen are interested in catching various species of fish, healthy ecosystems are preferred and thus river continuity is beneficial to this stakeholder group.

STAKEHOLDERS OPPOSING RIVER CONTINUITY RESTORATION

Industries (energy sector)

Those who oppose the restoration of river continuity are the ones who support river barrier installations, like the industries. The energy sector directly profits from the hydropower generation by dams, so they are unlikely to agree with removing their dam or prevent the construction of another. Since there is a need for an energy transition towards renewable energy sources, the hydropower businesses supposedly directly hinder river continuity and its restoration.

Landowners

The stakeholders that can be a limiting factor in river restoration - depending on the situation - are landowners, being the farmers or social representatives that own the land adjacent of the rivers. They have to be convinced (e.g. with financial compensation or land reallocation) that for instance widening the river that borders their land is beneficial on a larger scale beyond their own advantages. In the case of dam removal, they could argue that they need the function of flood control that is provided by the dam, so their land is less likely to overflow.

STAKEHOLDER CONFLICT/OPPOSITION

In practice, we sometimes see conflicts or oppositions arising between various stakeholders in the issue of river continuity restoration. Even a single stakeholder or one group of stakeholders can be in conflict of interests, as already became evident as river continuity restoration is beneficial for many ecological reasons, but so is renewable energy. This can be the case for some NGOs promoting river continuity restoration, while also promoting the development and use of renewable energy sources (Drouineau *et al.*, 2018). This, as well as the conflicts that may arise between various land and/or barrier owners, lead to the fact that the topic river continuity restoration often provokes discussions.

Countries can differ in their starting point and social constraints to achieving certain objectives. For some countries river continuity restoration is an issue mentioned in many (national) political debates. For instance, in the Southwest region of Spain there is strong political resistance to river continuity measures that also affect irrigation, due to the high monetary value of irrigated crops in this area (Del Tánago *et al.*, 2012). The involvement of politicians can result in accentuation on short-term gains (Newson & Large, 2006). Besides, the extra time that is necessary for the political discussion to be held are added on top of the duration of the introduction of (new) policies and regulations.

Lastly, public opposition to ecological restoration activities can result in rebellious actions or citizen demonstrations, which can force contributing parties to cease their activities. For a river restoration project in the River Alt (England) the locals were not consulted for the design of the project before construction, even though local authorities owned the land and the project was financed by public funding (Eden & Tunstall, 2006). This has led to vandalism by locals during the construction. Such stakeholder reluctance can be prevented by working closely together and good communication about the reason for restoration or removal (Lejon, *et al.*, 2009), creating mutual understanding of the necessity of adaptation.

Conflicts between stakeholders prevent an effective implementation of river continuity restoration. All stakeholders, whether supportive, opposing, or neutral on river continuity restoration, must work together or at least respect each other's needs and interests. If all stakeholders keep in mind the various goals and how their own activities do not hinder the goal of others, the most balanced and acceptable outcome for all can be the result. Proactive actions from politicians, policymakers, private companies, NGOs, and individuals are necessary to protect and restore rivers so their services can be used in the future (Weng, 2005). This requires full stakeholder participation.

7 The pan-European river continuity survey

WHY?

Undisturbed river continuity - free-flowing and without artificial barriers - is important for the hydro-morphological and ecological status and potential of a river. Recent studies and inventories indicate that the degree of river fragmentation by artificial barriers is remarkably high in many regions and countries of greater Europe and river restoration is considered the most progressive mechanism to improve this. Therefore, the ECRR has decided to raise awareness, disseminate information and develop knowledge and practices to support river continuity restoration.

They subsequently recognized that there is currently no overview on the longitudinal river continuity restoration policy, planning and implementation status of the various countries. Therefore, this project is set up to investigate the situation of each country to clarify the general and country specific demands and the support that is needed. European and national governmental policies and programs supported by NGOs and (knowledge) networks (such as the ECRR) can together contribute to the specific river restoration goal of longitudinal continuity.

The answers to this survey allow conclusions to be drawn, recommendations to be made, and advices to be formulated, while all this information might be used to propose and develop (new) policies and generate support. This could eventually be developed into a Europewide, openly accessible database, assisting national governments and river authorities in restoring river continuity. This will be beneficial for all the participating countries for achieving the relevant water legislation targets and UN Sustainable Development Goals.

WHO?

In the past three years, several consultations on the main issues have been made by the ECRR and form the basis for this survey. This questionnaire has only been sent to selected organizations / persons. One of them in each country, being qualified and authorized to provide the requested information. This has been almost in all cases a governmental department or agency / representative. These organizations / persons could of course consult other organizations / people in their country for filling out the questionnaire. ECRR provided a special contact person per country who could explain the questionnaire and its objectives and assist in the process.

WHAT?

With this questionnaire the current situation in every participating country regarding the recognition of river continuity in national policies and the potential for restoring river continuity has been investigated. Knowing the country specific situations, additional questions have given insight to define what this means for policy and support. What should be the main strategy per country and/or group of countries? This has been analysed through questions to national governments that have been covered by the following topics:

1. Recognition of river continuity in current national policies
    a. National policies and/or strategies
    b. Permits of the functional use
    c. River Basin Management Plans
    d. Barrier prioritization
    e. Measures to address barriers
    f. River continuity as an issue in national debates
    g. Financial instruments
2. The potential of river continuity restoration in your country
3. AMBER Barrier Atlas country information
4. Biodiversity Strategy 2030 ambition

5. Observations/opinions on the importance of and opposition to river continuity restoration
    a. The importance of river continuity restoration
    b. Local conflict/opposition / Societal pressure
    c. Improvements
    d. Management planning: from idea to implementation
    e. Research
    f. Suggestions

BY WHOM?

The Principal of the survey is the ECRR Board, see www.ecrr.org

The survey is implemented under the supervision of an ECRR Steering Committee composed of representatives of ECRR member organizations:

- Josée Peress, French Agency for Biodiversity (OFB)
- Saija Koljonen, Finnish Environment Institute (SYKE)
- Arjan Berkhuysen, World Fish Migration Foundation (WMFM)

The implementation Project Group is composed as follows:

- Sharelle Verheij, Dutch Foundation for Applied Water Research (STOWA) and ECRR
- Bart Fokkens, European Centre for River Restoration (ECRR) Coordinator
- Tom Buijse, Dutch Institute for Applied Water and Subsurface Research (Deltares)
- Martijn van Staveren, Wageningen University and Research (WUR)
- Bas van de Wal, Dutch Foundation for Applied Water Research (STOWA)

8 Definitions used in the survey

Although the wording that is used for the subjects discussed in the survey can generally differ amongst some countries, the following terms are used throughout the questions.

RIVER CONTINUITY

River continuity refers to the possibility for water, sediment, and aquatic fauna to pass freely upstream and downstream along the river (longitudinal continuity), laterally with the floodplain (lateral continuity) and in a vertical direction from riverbed interstitial areas and groundwater. This questionnaire is primarily focused on the improvement of longitudinal connectivity. River continuity can be seen from a number of different perspectives:

- Fish migration restoration
- Adaptive management of barriers
- (National) policies and strategies of improving river continuity
- Removing hydromorphological pressures
- Removing obsolete hydropower dams
- Protection against floods & droughts
- Etc.

RIVER CONTINUITY RESTORATION

To restore river continuity, removal of barriers is the most effective solution to increase exchanges and passage within the river corridor. Other solutions targeting longitudinal continuity can reduce the impacts of barriers by putting in place fish-passes to target fish migration, (partial) restoration, compensation and/or mitigation of river flows, or (temporary) solutions such as managing hydraulic structures or water resources.

ARTIFICIAL BARRIERS

An artificial barrier is a manmade structure which creates an obstacle in rivers. Any artificial structure presents a barrier to downstream movement of sediment and water and an obstacle for fish passage and migration of other aquatic fauna in both upstream and downstream direction. These barriers in a river can disrupt the river continuity by fragmenting the river passage and fluvial habitats besides longitudinal even in the lateral direction of the river. This fragmentation alters exchanges and passage within the river corridor and river connectivity on which ecological processes depend. As a result, the diversity of habitats and biota can be modified or reduced. Artificial barriers include dams, weirs, culverts, fords, sluices, and ramps (according to the AMBER project categorization).

- A *dam* blocks or constrains the flow of water and raises the water level, forming a reservoir
- A *weir* regulates flow conditions and water levels, intercepts sediment, and/or reduces the channel slope for stabilizing the channel bed of a river or stream
- A *culvert* allows a stream or river to flow through/under an obstruction
- A *ford* creates a shallow place for crossing by vehicle or on foot
- A *sluice* can be opened or closed to control water levels and flow rates
- A *ramp/bed* sill is an underwater structure that stabilizes the channel bed and reduces erosion

9 Survey results

COUNTRIES, CONTACT PERSONS & COORDINATORS OVERVIEW

In table 1 below the participating countries are listed, and for each of the countries the contact person and the participating organizations are indicated. The contact person reached out to the right people for the country/countries they have been the contact person for. The contacted people are the participants, who ensured the survey was filled out for their country. This was in most of the cases done together with colleagues or other people in their network. The table shows a total of 29 European countries. About 20 remaining European countries are not included in the table nor the results. These countries have been contacted, but they could not participate at this time, or they were not willing to do so. For these countries, a later moment in time could be suitable to still answer the questions from this survey. Their answers can then be analysed to get the same type of results from the whole of Europe.

TABLE 1

List of the participating countries and organizations in the ECRR river continuity survey 2021.

Country	Contact person	Organization	Participating organization
Austria	Alexander Zinke	Ministry	Federal Ministry of Agriculture, Regions and Tourism
Bosnia and Herzegovina	Bart Fokkens	ECRR	Ministry of Foreign Trade and Economic Relations
Croatia	Bart Fokkens	ECRR	Hrvatske Vode - Legal entity for water management
Cyprus	Bart Fokkens	ECRR	Republic of Cyprus Ministry of Agriculture, Rural Development and Environment
Denmark	Bart Fokkens	ECRR	The Danish Ministry of Environment
Estonia	Jukka Jormola	SYKE Finland	Environmental Ministry Estonia
Finland	Saija Koljonen	SYKE Finland	SYKE Finland
France	Josée Peress	OFB France	OFB France
Germany	Bart Fokkens	ECRR	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Hungary	Danka Thalmeinerová	Ministry of Interior	General Directorate of Water Management Hungary
Ireland	John Wheatland	The River Restoration Centre (RRC)	Environmental Protection Agency (EPA)
Latvia	Bart Fokkens	ECRR	Ministry of Environmental Protection and Regional Development of the Republic of Latvia
Lithuania	Bart Fokkens	ECRR	Ministry of Environment of the Republic of Lithuania
Malta	Bart Fokkens	ECRR	Environment & Resources Authority
The Netherlands	Bas van der Wal	STOWA	STOWA
North Macedonia	Bart Fokkens	ECRR	Ministry of Environment and Physical Planning
Norway	Andreas Lium	Environmental Agency Norway	Environmental Agency Norway
Poland	Mateusz Grygoruk	SSGW Poland	SSGW Poland
Portugal	Eve Garcia Burgos	CIREF	Agencia Portuguesa do ambiente
Romania	Danka Thalmeinerová	Ministry of Environment and Forestry	Romania Ministry of Waters and Forests
Russia	Timur Pavluk	RosNIIVHk Russia	RosNIIVHk Russia
Slovakia	Danka Thalmeinerová	ECRR Board Slovakia	Ministry of Environment
Spain	Eve Garcia Burgos	CIREF	Spanish Ministry for Ecological Transition
Sweden	Erik Årnfelt	EA Sweden	EA Sweden
Switzerland	Bart Fokkens	ECRR	Federal Office for the Environment
UK: England	John Wheatland	RRC	Environment Agency
UK: Northern Ireland	John Wheatland	RRC	Inland Fisheries Ireland
UK: Scotland	John Wheatland	RRC	Scottish Environment Protection Agency (SEPA)
UK: Wales	John Wheatland	RRC	National Resource Wales (NRW)

A total of 29 out of the 49 contacted countries, covering more than 80% of the area (figure 1), have participated in the survey until February 1st, 2021. If any more submissions are sent in after that date, they can still be used in future analyses or follow-up research. The participants mainly consist of specialists and senior research officers at environmental ministries, nature agencies, and marine and riverine knowledge institutes for water resources management. The personal information and background of all contributors will be used for ECRR's own overview and future reference if necessary. They will not be shared with any third parties, and are therefore not included in this report.

FIGURE 1

The 29 participating countries (green) in the ECRR river continuity survey 2021.

The survey questions and their answers will be examined per overarching topic of questions:

1. RECOGNITION OF RIVER CONTINUITY IN CURRENT NATIONAL POLICIES

For EU member states the Water Framework Directive (WFD) is an essential driver to restore river continuity. It is an EU water legislation which commits European Union member states to achieve good ecological and chemical status of all water bodies in the EU, both qualitative and quantitative. (For heavily modified or artificial water bodies the target is good ecological potential.) Coupled with the WFD, drafting River Basin Management Plans is required for EU member states. These plans are a means of achieving the protection, improvement and sustainable use of the water environment across Europe.

Other countries ratified the UNECE Water Convention on the protection and use of transboundary watercourses and international lakes. This is an international legal instrument and intergovernmental platform which aims to ensure the sustainable use of transboundary water resources by facilitating cooperation. Initially considered a regional instrument, it has been opened for access to all UN Member States in 2016.

To identify the effectiveness of present policies and their implementation and a potential need for other instruments, it is important to understand the current situation of national policies regarding river continuity in the countries. All the questions in this survey are therefore about your country and its current national policies and approved plans. Is river continuity restoration already on the agenda in your country? If so, what are the drivers and which barriers are prioritized for measures? The barriers that we are interested in are all barriers, so all those mentioned in the definitions (dams, weirs, culverts, fords, sluices, and ramps) in both major and minor rivers.

ARE THERE ANY NATIONAL POLICIES AND/OR STRATEGIES OPERATIVE IN YOUR COUNTRY TO RESTORE RIVER CONTINUITY?

FIGURE 2

Distribution of the number of countries that do (green) and do not (red) have any national policies and/or strategies operative to restore river continuity. (n=29).

While most countries (n=24, 83%) answered yes, 5 countries (17%) do not have any national policies and/or strategies operative to restore river continuity (figure 2). As answers to "**Why not?**", these countries do address broader and overarching aspects of water courses through the implementation of the EU Water Framework Directive, but no policy documents specifically targeting river continuity are adopted (Malta). River continuity is either addressed in a more comprehensive River Basin Management Plan (Croatia) or in a national strategy as a whole (Russia), or there are higher priorities such as pollution prevention (Latvia). For one country there are several fields of jurisdiction that decide which legal bases are implemented at administrative bodies (Bosnia and Herzegovina). For those countries that do have policies that include river continuity restoration, the 3 following questions apply:

TO WHAT EXTENT IS RIVER CONTINUITY RESTORATION IN NATIONAL POLICY DRIVEN BY THE DRIVERS LISTED BELOW?

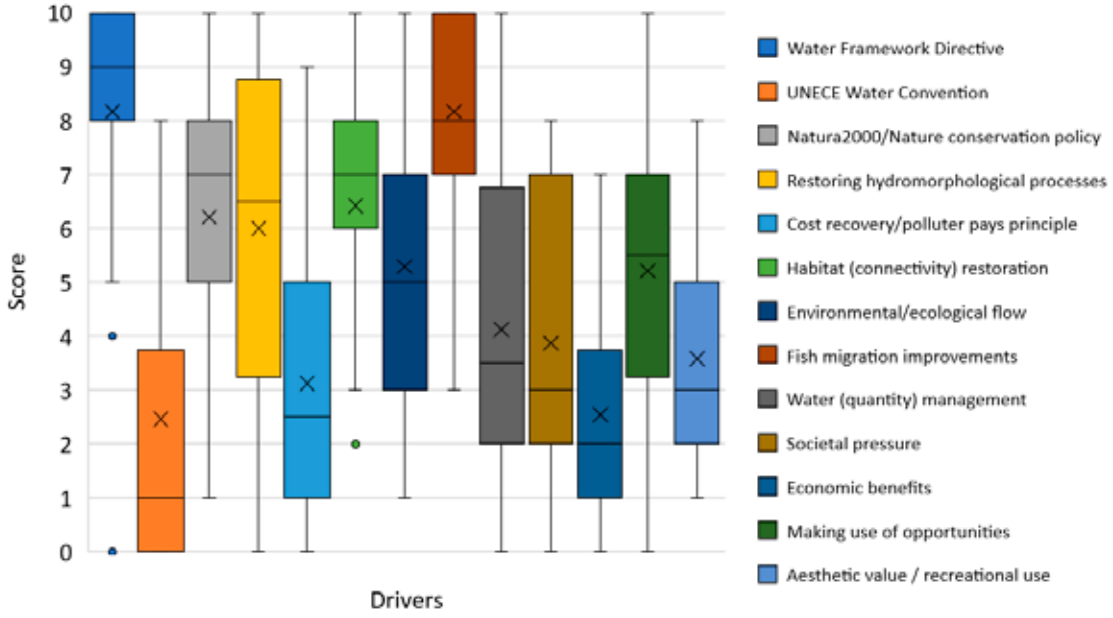


FIGURE 3

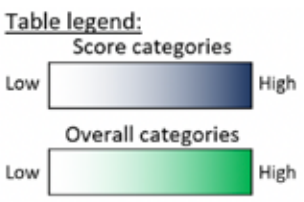
Boxplots of the drivers towards river continuity restoration in national policies on a scale of 0 (not applicable) to 10 (highest priority). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values, and the dots are outliers. (n=24).

As figure 3 shows, the EU Water Framework Directive has the highest average value (mean = 8.2), so this driver has been scored the highest overall by the countries that have a national policy and/or strategy to restore river continuity. On the other hand, the UNECE Water Convention is scored the lowest on average (mean = 2.5). This can be explained by the fact that the EU WFD has been adopted at a later time than the UNECE Water Convention (2000 vs. 1992) (European Commission, 2020a; UNECE, 2020). Even though the UNECE Water Convention is a UN wide legal instrument, and the WFD only applies to EU member states and a few other countries (Norway and Liechtenstein), all these states switched from the UNECE to WFD when it was adopted and put to practice. The second highest scored driver is fish migration improvements (mean = 8.2), after which habitat (connectivity) restoration (mean = 6.4) and Nature2000/nature conservation policies (mean = 6.2) score highest. These three drivers, together with restoring hydromorphological processes (mean = 6.0) are all ecological drivers, which are facilitated by the WFD, explaining why these drivers all score higher on average than the others. For some drivers, the spread of the boxplot covers scores 0 up to 10, meaning the importance of these drivers vary a lot per country. This is the case for the restoration of hydromorphological processes, water (quantity) management (so floods and droughts) and making use of opportunities. The scores per country are shown in colour categories in table 2. Almost every country scored at least one or two drivers very low, but North Macedonia scored every one of them relatively high (table 2). The countries that might need attention when it comes to driving them to restore the river continuity are Norway, Ireland, Northern Ireland, Spain, Sweden, Hungary and Poland.

TABLE 2

Given answers to the question 'To what extent is river continuity restoration in national policy driven by the drivers listed below? Scale: 0 (not applicable = low) to 10 (highest priority = high)' by each country including the overall score of each country and each driver.

	Water Framework Directive	*Fish migration improvements*	*Habitat (connectivity) restoration*	*Natura2000 / Nature conservation policy*	*Restoring hydromorphological processes*	*Environmental/ ecological flow*	*Making use of opportunities e.g. obsolete structures that can easily be removed*	*Water (quantity) management (flood and droughts)*	*Societal pressure e.g. citizen demonstrations leading to pressure on barrier owners*	*Aesthetic value / recreational use*	*Cost recovery / polluter pays principle*	*Economic benefits*	*UNECE Water Convention*	*Overall*
Republic of North Macedonia														
Austria														
Scotland (UK)														
France														
England (UK)														
The Netherlands														
Cyprus														
Estonia														
Denmark														
Germany														
Romania														
Lithuania														
Finland														
Wales (UK)														
Slovakia														
Portugal														
Switzerland														
Poland														
Hungary														
Sweden														
Spain														
Northern Ireland (UK)														
Ireland														
Norway														
Overall														



TO WHAT EXTENT IS RIVER CONTINUITY RESTORATION IN NATIONAL POLICY CONFLICTED BY THE BARRIER FUNCTIONS LISTED BELOW?

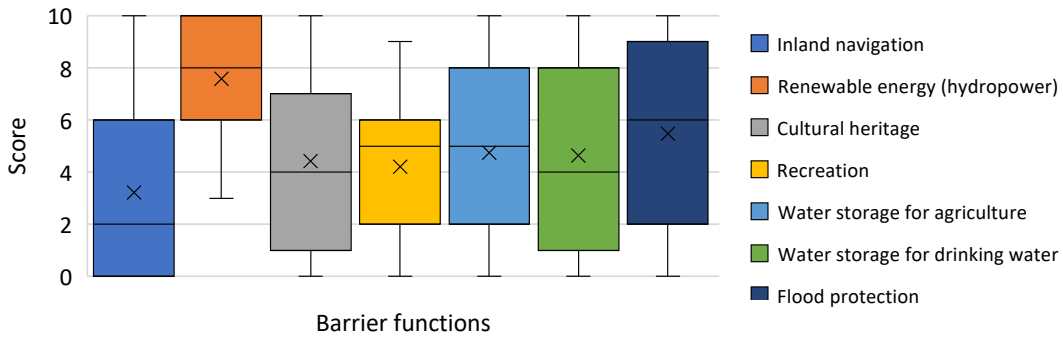


FIGURE 4

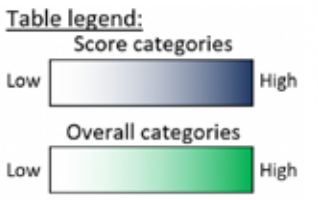
Boxplots of the barrier functions conflicting river continuity restoration in national policies on a scale of 0 (not applicable) to 10 (most substantial). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values. (n=24).

Hydropower is the highest scored function that conflicts with river continuity restoration policies (mean = 7.5), while inland navigation appears from the answers to only be an opposing function to a small extent (mean = 2.9) (figure 4). Cultural heritage is scored 4.5 on average, even though it has been stated in literature that this is an important function that is offered by some river barriers (Born *et al.*, 1998). The same applies to recreation that is on average scored 4.0, though from literature it has become evident that recreation is the only function that is left for the majority of the dams that still exist (Hoenke *et al.*, 2014). The results therefore contradict literature if we look at the average values from the answers to this question. However, for almost every function that is listed, answers from 0 to 10 are given, meaning there are great differences between the participating countries on whether or not these functions conflict with the national policies on river continuity restoration. This makes sense, as for instance renewable energy is mainly applicable for elevated countries, where hydropower generation is possible through height differences, while some flat countries like the Netherlands only have a slim possibility of generating hydropower through dams (Manzano-Agugliaro, Taher, Zapata-Sierra, Juaidi & Montoya, 2017). The conclusions should therefore be nuanced due to various aspects that play a role in the several countries. The scores per country are shown in colour categories in table 3.

TABLE 3

Given answers to the question 'To what extent is river continuity restoration in national policy conflicted by the barrier functions listed below? Scale: 0 (not applicable = low) to 10 (most substantial = high)' by each country including the overall score of each country and each function.

	Inland navigation	*Recreation*	*Water storage for drinking water*	*Cultural heritage*	*Water storage for agriculture*	*Flood protection*	*Renewable energy (hydropower)*	*Overall*
Hungary								
Austria								
Denmark								
Norway								
Northern Ireland (UK)								
Switzerland								
Sweden								
Germany								
Estonia								
Cyprus								
Finland								
Poland								
Scotland (UK)								
Republic of North Macedonia								
The Netherlands								
Wales (UK)								
Romania								
Slovakia								
Spain								
Lithuania								
England (UK)								
Portugal								
Ireland								
France								
Overall								



In this case a high score depicts a negative trait, as this translates to a barrier function that conflicts with the restoration of river continuity. Hungary did not score any of the functions very high, so river continuity restoration is not obstructed by many things (table 3). The countries that are obstructed when it comes to river continuity restoration are France, Ireland, Portugal, England and Lithuania. For these countries complete barrier removal is made difficult, but alternative solutions to restore the river continuity – such as adding a fish passage – are investigated and/or already being implemented.

TO WHAT EXTENT DO STAKEHOLDER GROUPS INFLUENCE THE POLICIES AND/OR STRATEGIES CONCERNING RIVER CONTINUITY RESTORATION IN YOUR COUNTRY?

The industries (i.e. the energy sector) has the highest average score (6.5) regarding the amount of influence they have on the policies and/or strategies concerning river continuity restoration in the participating countries (figure 5). They exert the greatest influence on the policies, which is most likely a negative influence in terms of river continuity restoration, given the fact that they are the ones who support river barrier installations, directly hindering river continuity restoration. The energy sector directly profits from the hydropower generation by dams, so they are unlikely to agree with removing these dams or prevent the construction of another. The next stakeholder groups that scored relatively high are NGOs (mean = 5.9) and the public sector with a mean of 5.5. The other stakeholder groups all have an average value of around 4.6. The given answers for all groups range from 0 or 1 to 9 or 10, suggesting the answers are very country dependent. The scores per country are shown in colour categories in table 4.

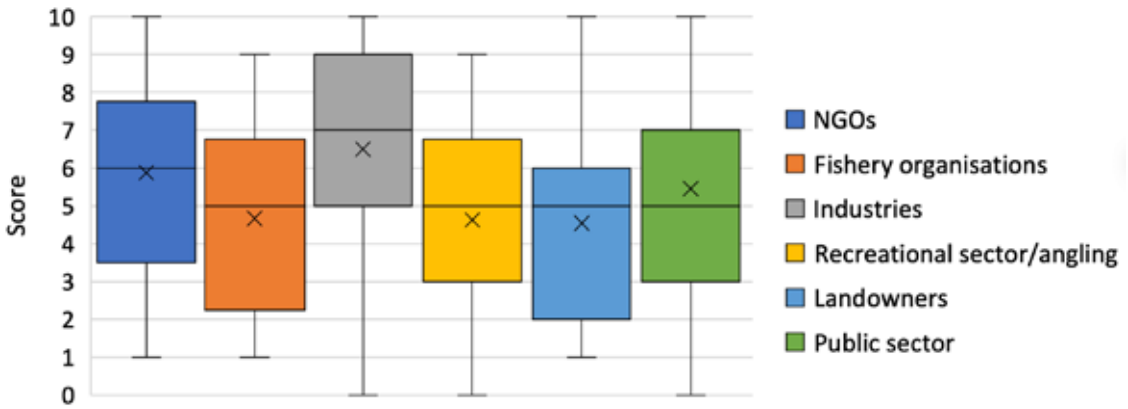


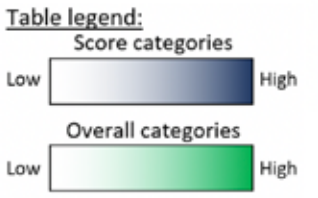
FIGURE 5

Boxplots of the stakeholder groups influencing national policies concerning river continuity restoration on a scale of 0 (not influential) to 10 (highest influence). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values. (n=24).

TABLE 4

Given answers to the question 'To what extent do stakeholder groups influence the policies and/or strategies concerning river continuity restoration? Scale: 0 (not influential = low) to 10 (highest influence = high)' by each country including the overall score of each country and each stakeholder group.

	Industries e.g. the energy sector	*NGOs*	*Public sector*	*Fishery organizations*	*Recreational sector/ angling*	*Landowners*	*Overall*
England (UK)							
Denmark							
Switzerland							
Slovakia							
Finland							
Netherlands							
Republic of North Macedonia							
Ireland							
Scotland (UK)							
France							
Romania							
Lithuania							
Portugal							
Wales (UK)							
Germany							
Northern Ireland (UK)							
Sweden							
Spain							
Cyprus							
Norway							
Hungary							
Austria							
Poland							
Estonia							
Overall							



Making use of stakeholder participation will be difficult for the countries that score on average very low (Estonia, Poland, Austria, Hungary, Cyprus and Spain), since only 1 or 2 stakeholder groups are indicated to be influential in these countries (table 4). A situation where all stakeholder groups are influential is preferred to make stakeholder participation possible. Though on the other hand, for Cyprus the potential for public participation seems to be very high, as the public sector is one of the two stakeholder groups that was scored very high. The fact that industries are scored very low by this country increase the potential to implement river restoration measures, though not all stakeholder groups will be satisfied with the outcome, making the process more complicated. For these countries that have very low mean scores, mediation techniques are required to use to get all stakeholder groups to agree.

HOW ARE THE FUNCTIONAL USES OF A BARRIER IN YOUR COUNTRY REGULATED?

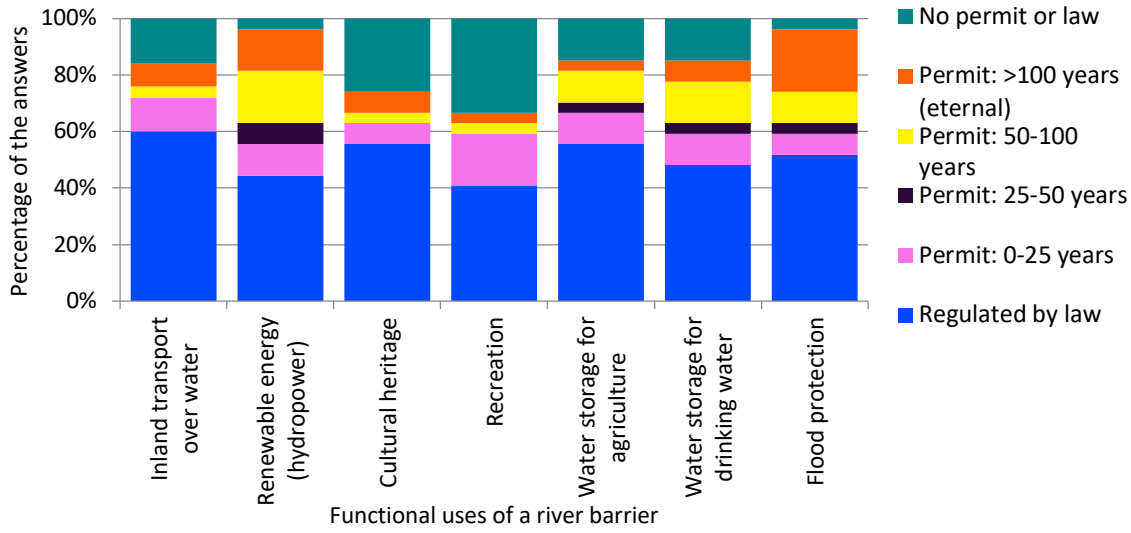


FIGURE 6

Stacked bar chart on the various regulations for each functional use of a river barrier. (n=28).

The results presented in figure 6 show how the various functional uses of a river barrier are regulated – either by law or permit – and how long the validity of the permit is. This differs greatly per function, especially for cultural heritage and recreation, of which it is indicated for both that they are mostly regulated by law (56% & 41%, respectively) or there is no law or permit at all (26% & 33%, respectively). For the other functions, the majority of the countries regulate them by law, except for renewable energy which is for the majority of the countries (52%) regulated by permits, with each time span of the permit validity being answered. For the other river barrier uses, the permits are mostly valid for a short time (lasting between 0 and 25 years), or a very long time (100+ years/eternal). Looking at the answers per country, most of the countries have a single regulation for each of the functional uses, meaning they are all regulated by either a law or permit and the permit validity is the same time span for each functional use. No country indicated for all the functional uses that they are not regulated by any permit or law. Another functional use of a barrier that is mentioned but was not included in the survey is groundwater recharge.

ARE THERE ANY LEGAL OBLIGATIONS TO REMOVE BARRIERS ONCE THEIR PERMIT ENDS?

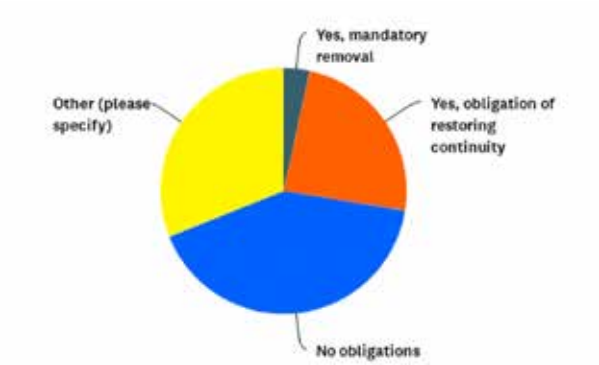


FIGURE 7

Distribution of the number of countries with and without legal obligations, and the type of legal obligation to remove a barrier once the permit ends. (n=29).

As a continuation of the previous question, a substantial number of the countries (n=12, 41%) does not have a legal obligation to remove a barrier after the validity of a permit has expired (figure 7). For 7 countries (24%) there is an obligation to restore the continuity of the river, and 1 country accounting for 3% of the total is required by law to remove the barrier. France, who has the obligation to restore the continuity, indicated that for 11% of its rivers this is regardless of whether the permit has ended or is still in effect. For a few who answered 'other' (n=9, 31%) it has been indicated that there are no obligations yet, but in the near future the WFD system will be implemented to legally require removal of barriers after a permit ends, by dealing with hydromorphological pressures including river continuity restoration (Croatia). Another country mentions that river connectivity has to be restored by adding or renovating the fish passage, while the barrier remains in place (Scotland). After a certain period of time, a permit can be revised and requested again (Hungary, Sweden). On the other hand, if a renewal of a permit is not requested the barrier does not necessarily have to be removed instantly, since this could in some cases lead to threatening of habitats (Germany). This question is therefore too general and should be dealt with case by case.

ARE THERE ANY RIVER BASIN MANAGEMENT PLANS MADE IN YOUR COUNTRY AND USED IN PRACTICE?

FIGURE 8

Distribution of the number of countries with (green) and without (red) any River Basin Management Plans. (n=29).

Figure 8 clearly shows that almost every participating country uses River Basin Management Plans. Only 1 country (North Macedonia) does not, because – as answer to "**Why not?**" – they are still in the process of development, so they will be adopted in the future.

HOW MANY RIVER BASIN MANAGEMENT PLANS ARE IMPLEMENTED IN YOUR COUNTRY?

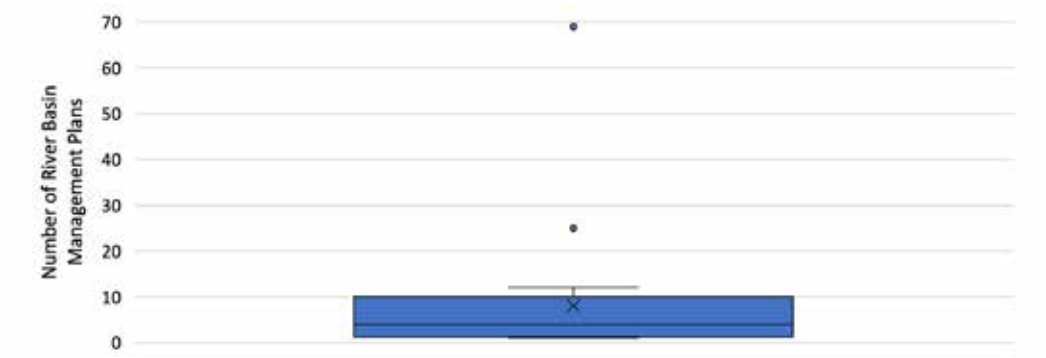


FIGURE 9

Boxplot of the number of River Basin Management Plans per country. The blue box indicates 50% of the scores that have been answered, while the cross indicates the average value, and the dots are outliers. (n=28).

Although most of the countries have a single to a handful of River Basin Management Plans, the average value per country is around 8 (figure 9). A few countries have 10 RBMPs, and the larger countries have a higher number of RBMPs, being France, Spain and Russia with 12, 25 and 69 RBMPs respectively, due to their large surface area that includes many river basins. Lastly, Switzerland has 26 cantonal plans.

IS RIVER CONTINUITY AN ISSUE SPECIFICALLY MENTIONED IN ANY OR ALL OF THE RIVER BASIN MANAGEMENT PLANS?

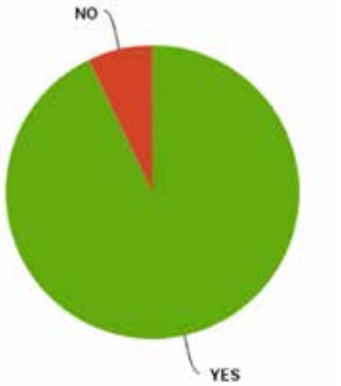


FIGURE 10

Distribution of the number of countries with (green) and without (red) river continuity mentioned in any or all of their River Basin Management Plans. (n=28).

There are only two countries (7%) that do not have river continuity mentioned in any or all of the RBMPs in their country (figure 10). This concerns Poland and Russia.

IS THERE A PRIORITY LIST IN YOUR COUNTRY OF BARRIERS WHERE RIVER CONTINUITY SHOULD BE IMPROVED, AND IF SO, IS THIS LIST OFFICIALLY ESTABLISHED?

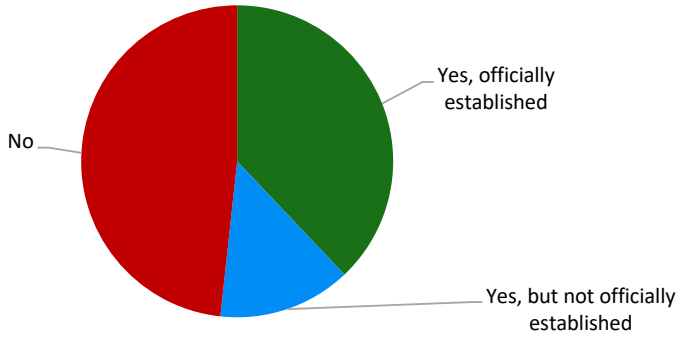


FIGURE 11

Distribution of the number of countries without (red) and with an officially established (green) or not officially established (blue) priority list of barriers where river continuity should be improved. (n=29).

Figure 11 shows there is a small majority (n=15, 52%) of the countries that do have a priority list of river barriers where river continuity should be improved, in contrast to those who do not (n=14, 48%). Answers to "**Why not?**", indicate this is because this list is still in development and is due to be adopted at a later time, or there is no list for the entire country but for parts of the country or the focus is on water bodies, or only the hydropower barriers are covered. For a few countries there is simply no obligation or strategy yet to come up with such a list. For the countries that do have such a list, 11 have officially established this list (38% of the total), while 4 countries (14%) have not.

FOR WHICH SCALE IS THIS LIST MADE?

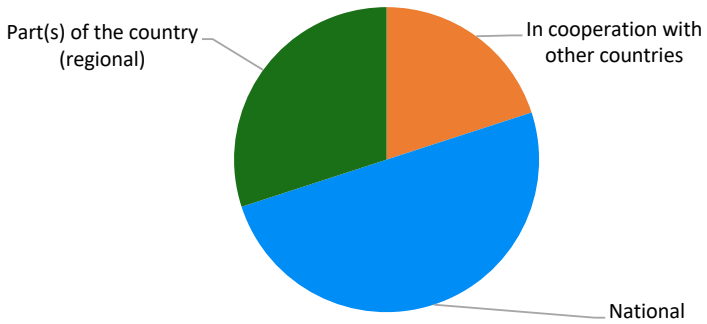


FIGURE 12

Distribution of the number of countries which established their priority list of river barriers where river continuity should be improved on a national (blue) or regional (green) scale, or in cooperation with other countries (orange). Multiple options for a single country are possible. (n=15).

This same priority list is established on different scales, for some countries even on multiple or all scales. This is the case for Germany, where 16 federal states are part of the country as a whole, which each have their own list as well as their own regulations and strategies. For the regulations around the Danube River, each country that includes part of this river is a contracting party of the International Commission for the Protection of the Danube River, the so called ICPDR countries. This regards Germany, Austria, Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Romania, Bulgaria, Moldova and Ukraine (ICPDR, 2020). The United Kingdom has a few internal partnerships between the concerning countries, and Germany, Belgium and the Netherlands are cooperating countries in the establishment of a barrier priority list. A few countries answered that the list is established on a regional scale, namely Northern Ireland, which established it for catchment levels, Spain and France both solely for river basin levels, and Switzerland for each individual canton. Overall, 50% is established nationally, while 30% is regionally and 20% established in cooperation with other countries (figure 12).

WHICH KIND OF BARRIERS ARE PRIORITIZED FOR MEASURES TO IMPROVE THE RIVER CONTINUITY?

Barriers with the largest environmental or ecological impact clearly scored highest (mean = 8.7). It can be argued that in practice the low hanging fruit are the first type of barriers that will be addressed to have measures, but apparently the barriers with the greatest impact are of high priority and are looked into to include measures (figure 13). However, this category together with the low hanging fruit do not exclude other types of barriers. It could be that the barriers with the largest environmental or ecological impact are also low hanging fruit, which can both consist of obsolete or small barriers for instance. For these two types of barriers (obsolete and small structures) the given answers are very country dependent. Perhaps some countries can remove these structures more easily than other countries. For high dams it is practically unanimous that these are not or barely addressed (mean = 1.5), although two countries indicated high dams to be of high or even the highest priority. This regards England and Estonia, who both gave the very same answers over all of the given types of barriers. Lastly, two suggestions were made for barrier types that were not included in the answers: barriers that need to be repaired and barriers with a permit for water use that is about to be expired. The scores per country are shown in colour categories in table 5.

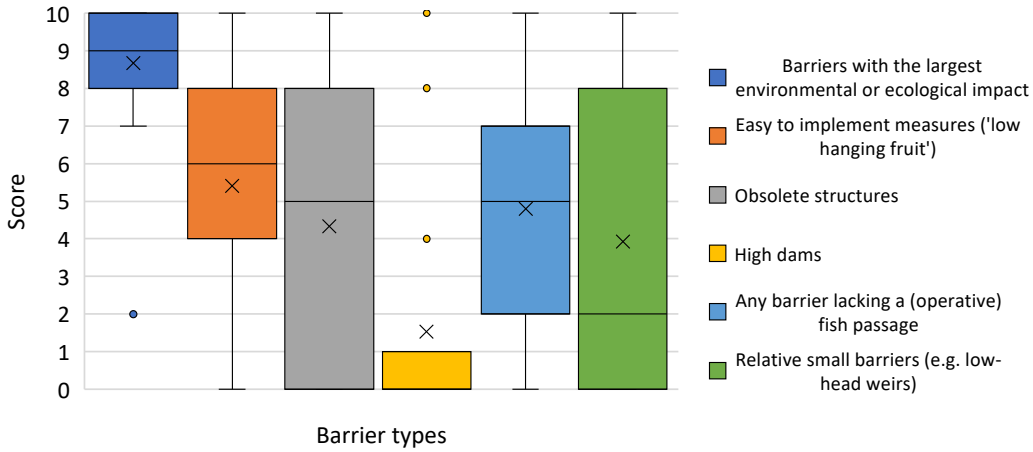


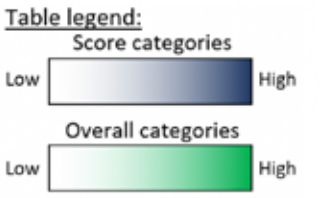
FIGURE 13

Boxplots of the type of barriers that are prioritized for measures to improve the river continuity on a scale of 0 (not considered) to 10 (highest priority). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values, and the dots are outliers. (n=15).

TABLE 5

Given answers to the question 'Which kind of barriers are prioritized for measures to improve the river continuity? Scale: 0 (not considered = low) to 10 (highest priority = high)' by each country including the overall score of each country and each barrier type.

	Barriers with the largest environmental or ecological impact	*Easy to implement measures ('low hanging fruit')*	*Any barrier lacking a (operative) fish passage*	*Obsolete structures*	*Relatively small barriers (e.g. low-head weirs)*	*High dams*	*Overall*
Estonia							
England (UK)							
Poland							
Netherlands							
Germany							
Switzerland							
Spain							
France							
Austria							
Scotland (UK)							
Romania							
Northern Ireland (UK)							
Latvia							
Lithuania							
Hungary							
Overall							



The fact that Estonia and England answered all of the types of barriers with the same score seems unlikely for high dams based on the answers of the others. Romania is the only country not scoring the first category 'barriers with the largest environmental or ecological impact' with a high number. Hungary scored this category with a '10', while all the others are scored to not be considered. In reality, this will probably not be the case as barriers with the largest environmental impact do not exclude the other categories of barriers. Overall, it is clear that every country might need some help with identifying the barriers that are important to consider for measures and coming up with a strategy to tackle them with a clear priority list.

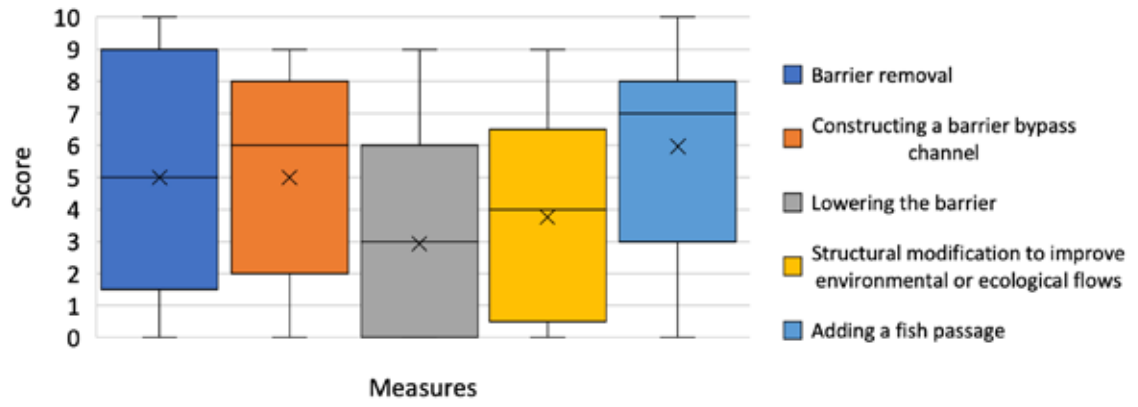


FIGURE 14

Boxplots of the type of measures that are applied to restore river continuity on a scale of 0 (not considered) to 10 (highest priority). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values. (n=28)

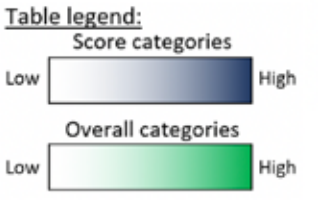
The measure that is or will be implemented first is the addition of a fish passage to an already existing river barrier (mean = 6.2). This way the use of the barrier remains intact. Then, the construction of a bypass channel follows together with barrier removal (mean = 5.2). This is an unexpectedly low score for barrier removal. Apparently, the complete removal of a barrier is not yet put into action to a large extent compared to other measures. Thus, our results contradict existing literature (Born *et al.*, 1998; Hoenke *et al.*, 2014; Poff & Hart, 2002). However, it makes sense as it is not always possible to remove a barrier for instance when it is used for hydropower generation. For a few countries, removal is scored high, up to a score of 10 (highest priority). This is the case for Wales, Scotland, Ireland, Denmark, and Cyprus. It could be that they scored removal high because these countries have relatively few hydropower dams compared to other European countries (Manzano-Agugliaro *et al.*, 2017). Lowering the barrier is scored lowest with a mean score of 3.0. Lastly, a few additions were listed: removing invasive and non-native plants that act as barriers, raising of watercourses that have been lowered at culverts and small dams. Overall, for each of the measures it is rather country dependent as to which one is applied more often or is considered more effective than others, seen from the fact that all the boxplots have a large range (figure 14). Therefore, table 6 is made to show all the given scores per country in colour categories. From this table some clear differences can be seen with Malta not applying any of the given measures, and Russia, Bosnia and Herzegovina, Latvia and Hungary only to a very small extent, while Wales, Poland, Scotland, and Spain apply them all relatively strongly.

One country skipped this question, because for Croatia it is hard to prioritise in the given ways. Croatia mentioned the following actions to be taken: For large hydropower generating dams, fish passages are constructed. On the other hand, most of the barriers are small but needed (such as culverts), and for those, reconstructions to ensure better connectivity would be the best approach.

TABLE 6

Given answers to the question 'Which measures are applied to restore connectivity or river continuity? Scale: 0 (not considered = low) to 10 (highest priority = high)' by each country including the overall score of each country and each measure.

	Adding a fish passage	*Constructing a barrier bypass channel*	*Barrier removal*	*Structural modification to improve environmental or ecological flows*	*Lowering the barrier*	*Overall*
Wales (UK)						
Poland						
Scotland (UK)						
Spain						
Ireland						
Estonia						
France						
Finland						
England (UK)						
Denmark						
Cyprus						
Sweden						
Germany						
Austria						
Portugal						
Lithuania						
Northern Ireland (UK)						
Republic of North Macedonia						
Romania						
Switzerland						
Slovakia						
Netherlands						
Norway						
Hungary						
Latvia						
Bosnia and Herzegovina						
Russia						
Malta						
Overall						



HOW OFTEN IS RIVER CONTINUITY MENTIONED AS AN ISSUE IN ANY POLITICAL DISCUSSIONS IN YOUR COUNTRY?

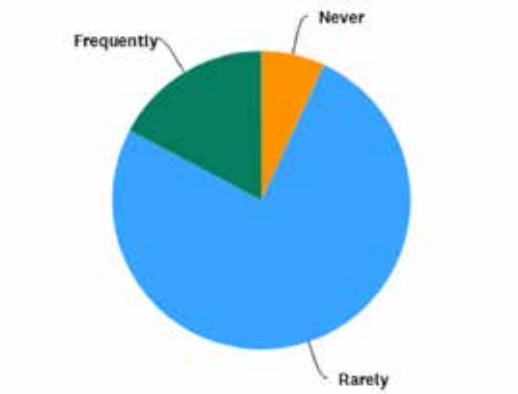


FIGURE 15

Distribution of the frequency of river continuity being mentioned as an issue in political discussions (never = orange, rarely = blue, frequently = green). (n=29).

Besides the three categories depicted in figure 15 (never, rarely & frequently), there was also the possibility to answer 'always' to the question how often river continuity is mentioned as an issue in any political discussion. This option has not been chosen once. While river continuity is rarely discussed in political discussions for the majority of the countries (n=22, 76%), there are five countries (17%) that frequently discuss this issue (Romania, Germany, Portugal, Finland & Austria). Two countries, who make up 7% of the total, indicated that river continuity is never on the political agenda (Estonia & Cyprus).

TO WHAT EXTENT ARE THE SOURCES OF FINANCES LISTED BELOW CURRENTLY AVAILABLE AND USED IN YOUR COUNTRY FOR THE RESTORATION OF RIVER CONTINUITY?

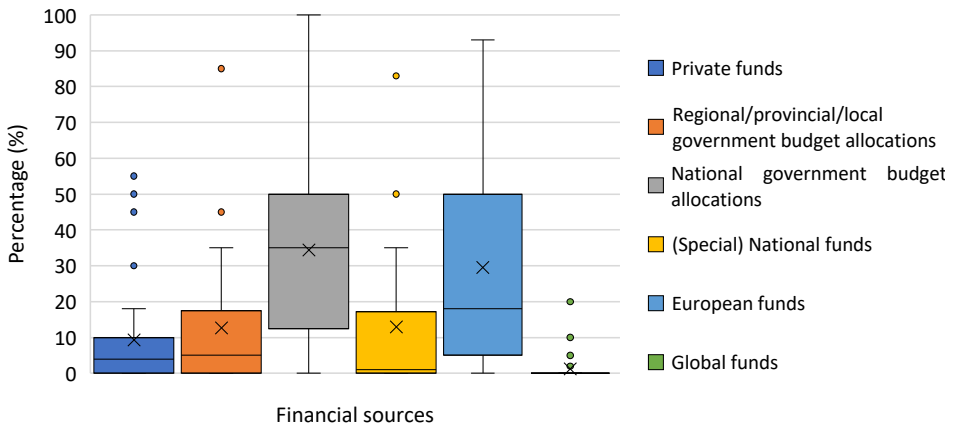


FIGURE 16

Boxplots of the financial sources that are available and used for river continuity restoration. The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values, and the dots are outliers. (n=29).

With the total finances that are available as 100%, there are barely any global funds that are available or used by the participating countries (mean = 1.3%). This makes sense as these budgets are mostly used by Eastern European countries, but these countries unfortunately are under-represented in the participants of the survey, while here most of the European dams are built. European funds are the primary financial source in Eastern European countries, while national government budget allocations are widely used in Western Europe, explaining the fact that these two boxplots have such a large range. These two financial sources are relatively widely available compared to the other financial sources. However, as national government budget allocations account for 34% on average and European funds for a mean value of 29%, they are not very highly available overall. The three remaining financial sources – private funds, regional government budget allocations and (special) national funds – each account for approximately 10% on average of all available financial sources (figure 16).

WHAT PERCENTAGE OF THE TOTAL POLICY GOAL OF YOUR COUNTRY CAN BE ACHIEVED WITH ALL THESE FINANCIAL INSTRUMENTS COMBINED?

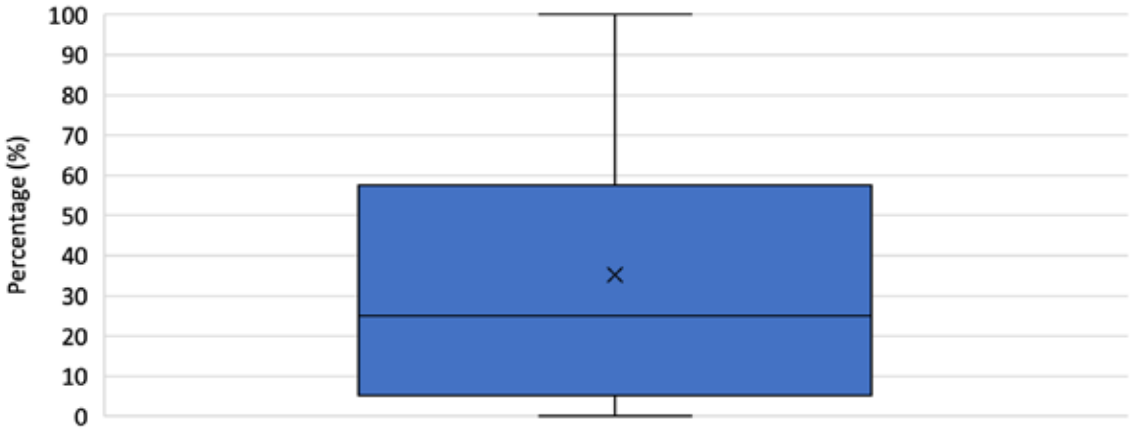


FIGURE 17

Boxplot of the percentage of the total policy goal that can be achieved with all the financial instruments combined that are available and used in a country. The blue box indicates 50% of the scores that have been answered, while the cross indicates the average value. (n=29).

A few countries have answered 0 (Malta, Russia & Norway) even though those countries did indicate to have access to a few financial instruments, and two countries have answered 100 (Austria & Denmark), which also seems somewhat unlikely. With these outliers taken into account, the average percentage of the total policy goal that can be achieved with the available financial instruments is equal to 35% (figure 17). This means that 65% of the goal cannot be achieved with the current financial situations across Europe. Budgets have to be increased or other forms of financial sources have to be accessed in order for the total goal of river continuity restoration to be achieved.

2. THE POTENTIAL OF RIVER CONTINUITY RESTORATION IN YOUR COUNTRY

DOES A NATIONAL DATABASE EXIST OF THE ARTIFICIAL BARRIERS IN YOUR COUNTRY?

FIGURE 18

Distribution of the number of countries that do (green) and do not (red) have a national database of the artificial barriers in the country. (n=29).

Figure 18 shows that the majority of the participating countries (n=21, 72%) has a national database on the artificial barriers in the rivers of the country. Eight countries (28%) do not have such a database (Wales, North Macedonia, Northern Ireland, Lithuania, Bosnia and Herzegovina, Cyprus, Denmark & Norway).

IS THE (TOTAL) NUMBER OF ARTIFICIAL BARRIERS IN (PART(S) OF) YOUR COUNTRY KNOWN?

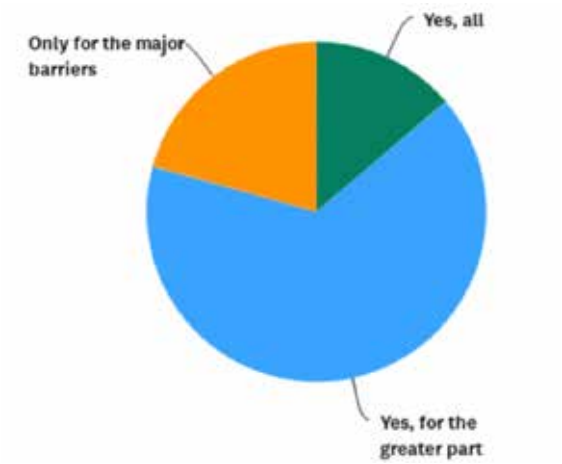


FIGURE 19

Distribution of the number of countries for whom the number of artificial barriers is known (green), partially known (blue), or known for the major barriers (orange). (n=29).

Besides the three categories in figure 19, one of the possible answers was 'no', meaning none of the numbers of artificial barriers is known. Fortunately, none of the participating countries has chosen this answer. For four countries (14%) the total number of all barriers is known, and for nineteen countries (66%) the number of barriers in the greater part of the country is known. The remaining six countries (21%) only have details of the major barriers in their country. This information is important to know what the answers to the following question is based on:

WHAT ARE THE (ESTIMATED) NUMBERS OF THE FOLLOWING ARTIFICIAL BARRIERS IN YOUR COUNTRY?

- *Total*
- *Currently have a fish passage*
- *Can be adjusted to include a fish passage*
- *Obsolete*
- *Obsolete and can be removed without conflicting the interests of the barrier owner*
- *Already have been removed*
- *Hydromorphological and ecological restoration measures to improve continuity are already planned to be taken*

The survey included a few questions where the recipients were requested to give the numbers of all the barriers in their country, as well as those for some barrier characteristics. The total number of barriers and the corrected (estimated) number of barriers per country, as obtained through the AMBER project (AMBER Consortium, 2020) are included in table 7 to compare them to the obtained numbers through this survey, which are also all listed in table 7. Not all countries were able to deliver the requested numbers, as these are still being investigated. Besides, the AMBER project did not include Russia, and the UK countries are grouped together, instead of individually as for the survey. The estimations were given in percentages, which have been quantified into numbers, based on the known total where possible. Overall, European wide there is still a long way to go to acquire all the information about the barrier numbers in each country.

A few countries have answered both the known and the estimated value for some barrier numbers, with the known value being continuously lower than the expected value given under the column 'estimation'. There have also been some ranges answered in the estimations. The totals at the bottom of the table (table 7) that indicate a range, apply for those categories where both the known and estimated values are answered, or a range is indicated by some countries. Besides, the percentages by Northern Ireland are not taken into account in the totals, as there was no total number of barriers supplied by this country to calculate the requested numbers.

The upper limit of the range from the total number of barriers shows there is an estimated maximum total of 680,227 barriers in all the participating countries combined. From this total, 9.5% is indicated to have a fish pass included, or the barrier is passable for fish already. For 46% of this total it is said that the barriers can be adjusted to include a fish passage. Evidently, 20% of the barriers is thought to be obsolete, and 7% of the total is an obsolete barrier that can be removed, meaning that a third of all obsolete barriers can be removed. The total number of barriers that have already been removed accounts for only 1% of all the barriers that are currently present. Lastly, 13% of the barriers are already planned to include hydro-morphological and ecological restoration measures.

TABLE 7

Given answers by each country to questions about the number of barriers for a few characteristics, and information on the total and corrected number of barriers per country as published by the AMBER consortium (AMBER Consortium, 2020). The asterisk (*) indicates a devised number, as the respondent's answer was 'several thousand'.

	AMBER information on all barriers		All barriers		With a fish passage		Can include a fish passage		Obsolete		Removable obsolete		Already removed		Planned hydro-morphological and ecological restoration measures	
	Total	Corrected	Known	Estimation	Known	Estimation	Known	Estimation	Known	Estimation	Known	Estimation	Known	Estimation	Known	Estimation
Wales (UK)	23,719 (UK)	48,293 (UK)														
Poland	16,171	77,530	16,453	35,000		3,500		31,500		9,872		2,468		50		823
Republic of North Macedonia	173	4,731	150	200	50		50		25		10			2		15
Ireland	1,532	8,436		9,500		<950		9,025		1,900-2,375		950-1,188	11			95
Malta				202						61		40	0		6	
Romania	791	18,095		2,500	220										52	
Croatia	113	889	5,794		4			2,318		869		435		30	185	
Germany	178,996	224,658		200,000		20,000		100,000		60,000		4,000		5,000*		70,000
Northern Ireland (UK)	23,719 (UK)	48,293 (UK)				60%		40%		60%		15%		10		
Russia			21,306		17					1,065-3,622						
Spain	29,882	171,203		25,000		619		20,000	3,053			2,748		350		1,500
Hungary	2,783	3,124	121		22		38		1		1			1	2	
The Netherlands	62,586	62,610	2,660		1,200		740			133		0	40		740	
England (UK)	23,719 (UK)	48,293 (UK)	23,067		>830								>103			
Scotland (UK)	23,719 (UK)	48,293 (UK)												37	317	
Portugal	1,197	16,095	157											<1%		
Lithuania	1,257	7,800	1,225	1,525	27		100			368			1		20	
Slovakia	152	7,378	1,075	2,000	117	1,000		323		11		11		11		376
Latvia	602	6,474		1,250	6			625		63-125		19-38	0			13
Estonia	187	7,939	990		100			396		891		99		20		10
Bosnia and Herzegovina	214	5,150		72	1			50					2			
Sweden	19,495	31,068		50,000		2,500		37,500		20,000		10,000		1,500		2,000
Cyprus	285	1,280		100	1			80		20		10	1			1
France	61,960	63,932		110,000		27,500		55,000		33,000		22,000		5,000		11,000
Finland	829	31,876		>30,000		4,500		24,000		3,000		2,700		50		600
Austria	27,407	43,189	57,168		1,295		28,589							500	1,500	
Denmark	3,066	4,176	615			123	600						100		615	
Norway	3,980	9,045														
Switzerland	145,461	171,693		101,000	150		1,000						600		1,000	
Total	**582,838**	**1,026,664**	**660,405 – 680,227**		**63,732 – 64,615**		**311,934**		**134,332 – 137,426**		**45,491 – 45,748**		**8,431**		**90,870**	
% of total	**-**	**-**	**100**		**9.5**		**46**		**20**		**7**		**1**		**13**	

The AMBER (Adaptive Management of Barriers in European Rivers) project has set up a barrier database to inventory the amount and types of barriers that are present in the European rivers, the so-called barrier atlas. By using this atlas, strategic and educated management plans can be made to enhance the health of European rivers.

IS THE INFORMATION ABOUT THE NUMBERS OF THE VARIOUS ARTIFICIAL BARRIERS IN YOUR COUNTRY PASSED ON TO THE AMBER PROJECT?

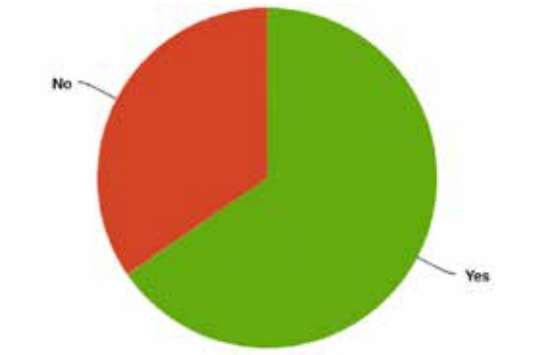


FIGURE 20

Distribution of the number of countries whose information about the numbers of the various artificial barriers is (green) or is not (red) passed on to the AMBER project. (n=26).

For a total of 17 countries (66%) the information about the numbers of the various artificial barriers in the country is known for AMBER, while 9 countries (35%) have not passed on this information to AMBER (figure 20). This is mainly due to a lack of resources (Wales & Finland), or the fact that the project is not relevant to the small-scale and unique 'rivers' in Malta (answers to the question: "**Why not?**")

On the 20th of May in 2020, the European Commission published the EU Biodiversity Strategy for 2030 'Bringing nature back into our lives'. The Strategy put forward new commitments for nature restoration, including freshwater ecosystems. The European Commission states that in order to achieve the objectives of the Water Framework Directive, the natural functions of rivers must be restored. The Commission aims to do this by restoring at least 25,000 km of rivers into free-flowing rivers through the removal of primarily obsolete barriers and the restoration of floodplains and wetlands.

DOES YOUR COUNTRY HAVE AMBITION TO CONTRIBUTE TO THE AIM OF THE BIODIVERSITY STRATEGY 2030?

As shown in figure 21, of the total of 29 countries, only 4 countries (14%) do not have the ambition to contribute to the aim of the Biodiversity Strategy 2030, so to restore 25,000 kilometres of rivers to be free flowing (Malta, England, Scotland & Switzerland).

FIGURE 21

Distribution of the number of countries that have (green) and do not have (red) the ambition to contribute to the aim of the Biodiversity Strategy 2030, so to restore 25,000 kilometres of rivers in Europe to be free flowing. (n=29).

WHAT IS/ARE THE ARGUMENT(S) FOR YOUR COUNTRY TO NOT CONTRIBUTE TO THIS INITIATIVE?

For Malta this is because their rivers are very small and generally restricted to watercourses with intermittent flows and fluctuating water levels. It is therefore difficult for Malta to significantly contribute to the goal. Switzerland and the UK countries are not or no longer in the EU, so any contribution to this plan is not legally obliged, though there are great opportunities to contribute anyway.

WHAT IS/ARE THE ARGUMENT(S) FOR YOUR COUNTRY TO CONTRIBUTE TO THIS INITIATIVE?

The 25 countries (86%) that do contribute to this goal mentioned among other things that some goals can (partly) be achieved with low-cost actions in the framework of standard and regular river maintenance measures. These measures are already applied, and no additional funding is needed to achieve the goal (Poland). With sufficient resource allocations, many barriers can be removed (Ireland). There is societal responsibility and political pressure to contribute to the goal (The Netherlands), which demands upstream countries to contribute. It is generally recognized that many barriers and rivers require improvement and restoration.

TO WHAT EXTENT ARE ATTEMPTS MADE IN YOUR COUNTRY TO REACH THIS GOAL?

With an overall mean of 5.6 and a wide range of the boxplot graph in figure 22, the extent to which attempts are made in the participating countries to reach the goal of the Biodiversity Strategy 2030 greatly differ over the whole of Europe.

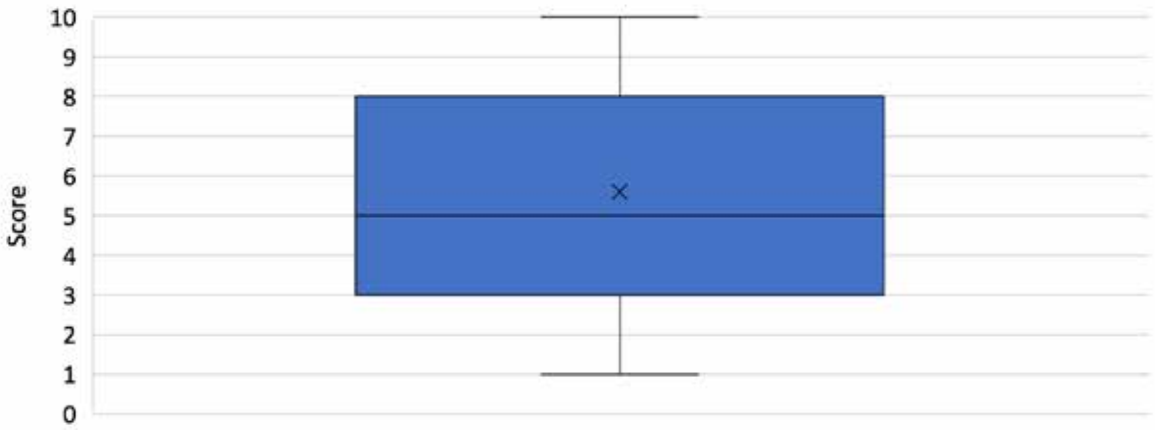


FIGURE 22

Boxplot of the extent to which attempts are made in the participating countries to reach the goal of the Biodiversity Strategy 2030 of restoring 25,000 km of rivers to be free flowing on a scale of 0 (no attempts at all) to 10 (anything that is possible). The blue box indicates 50% of the scores that have been answered, while the cross indicates the average value. (n=25).

COULD YOU GIVE AN EXAMPLE OF WHAT IS DONE IN PRACTICE TO ACHIEVE THIS GOAL?

To work towards restoring 25,000 kilometres of rivers to be free flowing a River Restoration Programme is established in Wales in which physical modifications are prioritized; a National Surface Water Restoration Programme is addressed in Poland; the government in Ireland has funded a project to identify and prioritize barriers for removal; a fish pass for Iron Gates I and Iron Gates II in Romania is in development; Croatia is working on a floodplain assessment which results should help in the assessment of possible actions; the first dam removal in Lithuania took place in July 2020; and many other conservation projects and strategies are in operation to restore 100 (Estonia), 400 and 1,260 (in two federal states of Germany), 2,000 (Poland), 3,000 (Spain), even up to 22,000 (Denmark) kilometres of rivers. For France, the goal of restoring 25,000 kilometres of rivers was already a goal for the country itself before the Biodiversity Strategy came into effect. (**To what extent is there an opportunity for your country to contribute to the goal of 25,000 kilometres of free-flowing rivers?**).

3. OBSERVATIONS/OPINIONS ON THE IMPORTANCE OF/OPPOSITION TO RIVER CONTINUITY RESTORATION

IN YOUR OPINION, HOW IMPORTANT IS RIVER RESTORATION IN YOUR COUNTRY?

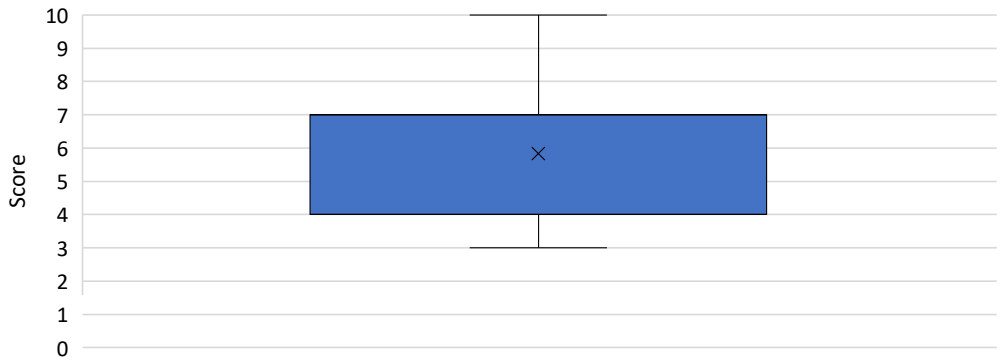


FIGURE 23

Boxplot of the level of importance of river restoration in the participating countries on a scale of 0 (not important at all / actively ignored) to 10 (highest priority). The blue box indicates 50% of the scores that have been answered, while the cross indicates the average value. (n=29).

Although the average value of the importance of river restoration in the participating countries equals 5.8, the most answered value is 7 with 11 out of the total of 29, making up 38% of the answers (figure 23).

HOW OFTEN DOES STRONG LOCAL CONFLICT/OPPOSITION EMERGE IN RELATION TO RIVER CONTINUITY RESTORATION PROJECTS?

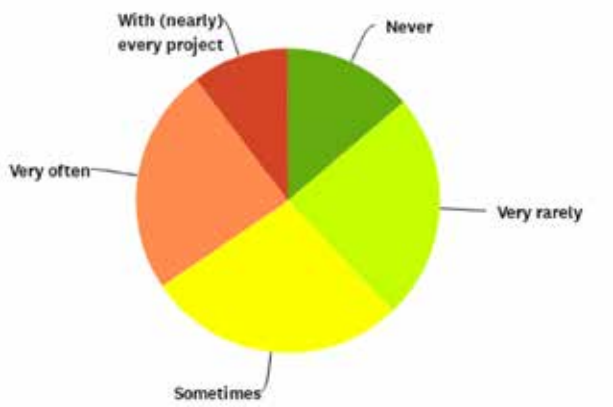


FIGURE 24

Distribution of the number of countries that observe strong local conflict/opposition in relation to river continuity restoration projects in various frequencies. (n=29)

Four countries (14%) never observe local conflict/opposition in relation to river continuity restoration projects (Malta, Romania, Bosnia and Herzegovina and Cyprus), while three countries (10%) do so with (nearly) every project (Poland, Ireland and Portugal) (figure 24).

IF YOU OBSERVE LOCAL CONFLICT/OPPOSITION WHEN RIVER CONTINUITY RESTORATION PROJECTS ARE PLANNED (BASED ON CASES IN HISTORY), PLEASE ELABORATE ON WHY AND HOW THIS CONFLICT STARTED.

The conflicts are indicated to arise from a strong cultural interest in weirs connected to old mills, as well as the preference from local anglers to keep a weir due to the localised pool that is created (Wales & France); local stakeholders (farmers) are afraid of floods, so a restored river will threaten their business (Poland); weir removal results in conflict due to archaeology, historical workings, potential flooding, personal attachment and financial disturbance depending on the use of the weir (Ireland); nature protection experts and local heritage conflict with the goals of water management and owners of small hydropower plants and landowners often do not agree with a barrier removal (Germany); some dams are used by waterfowl and/or recreational purposes (Norway). In general, the agricultural farmers/ landowners fear natural threats and the interests of the energy sector are not respected with barrier removals. Besides, citizens often oppose change.

TO WHAT EXTENT ARE THE FOLLOWING ACTIONS USED IN YOUR COUNTRY TO IMPROVE THE QUANTITY AND/OR QUALITY OF RIVER CONTINUITY RESTORATION?

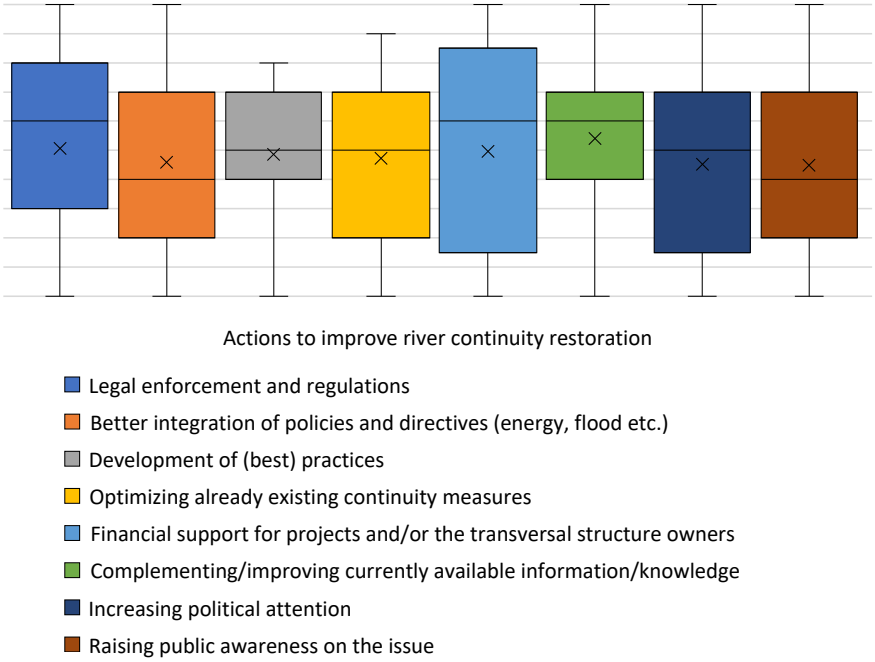


FIGURE 25

Boxplots of the actions that are carried out to improve the quantity and/or quality of river continuity restoration on a scale of 0 (not used at all) to 10 (strongly performed). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values. (n=29).

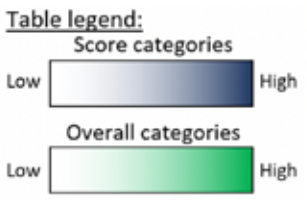
There seems to be no clear distinction in which action is used more often than others (figure 25). Each action has a mean value around 5 and the answers range from 0 to 10 for almost every action. Only legal enforcement and regulations and financial support for projects and/or the transversal structure owners stand out due to the inner range reaching up to a score of 8 and 8.5, respectively. Besides, complementing/ improving currently available information/knowledge has a slightly higher average score than the other actions. Lastly, the highest score for development of (best) practices is the lowest compared to the other highest scores. Overall, the boxplots are quite similar, so we will therefore look at the answers per country (table 8).

From this table with colour categories it becomes clear that some countries need attention when it comes to taking actions to improve the quantity and/or quality of river continuity restoration efforts. This regards Latvia, Bosnia and Herzegovina, Malta, Hungary, Cyprus, Croatia, Ireland, Russia, Norway and Poland. The countries that already implement most of the actions to a high extent are Austria, North Macedonia, Wales, Slovakia, France, Denmark and the Netherlands.

TABLE 8

Given answers to the question 'To what extent are the following actions used in your country to improve the quantity and/or quality of river continuity restoration? Scale: 0 (not used at all = low) to 10 (strongly performed = high)' by each country including the overall score of each country and each action.

	Complementing/ improving currently available information/ knowledge	*Legal enforcement and regulations*	*Financial support for projects and/or the barrier owners*	*Development of (best) practices*	*Optimizing already existing continuity measures*	*Better integration of policies and directives*	*Increasing political attention*	*Raising public awareness on the issue*	*Overall*
Austria									
Republic of North Macedonia									
Wales (UK)									
Slovakia									
France									
Denmark									
Netherlands									
Finland									
Romania									
England (UK)									
Scotland (UK)									
Spain									
Lithuania									
Germany									
Switzerland									
Portugal									
Estonia									
Sweden									
Northern Ireland (UK)									
Poland									
Norway									
Russia									
Ireland									
Croatia									
Cyprus									
Hungary									
Malta									
Bosnia and Herzegovina									
Latvia									
Overall									



MANAGEMENT PLANNING: FROM IDEA TO IMPLEMENTATION

The operation time span can vary per case, where the amount of time that is necessary to implement an idea can in practice be either short or long. Here, we would like to know what the general situation in your country is regarding the implementation time that is used to take measures on barriers (e.g. include a fish passage or remove the barrier as a whole).

PLEASE PROVIDE ONE EXAMPLE WHERE THE DURATION OF THE IMPLEMENTATION FROM THE START OF THE AGENDA SETTING WAS VERY SHORT

There are several examples of projects that included measures on barriers with a short operation time frame from idea until implementation: 2 years from bidding for EU LIFE funding to removal of a dam (Wales); Consultation to construction of fish passes in 3 years-time (Poland); Small river maintenance measures without legal procedure with availability of money only take up to 6 months, and a fish pass construction took only 3 years (Germany); Kisköre Fish pass installation in 4 years (Hungary).

PLEASE PROVIDE ONE EXAMPLE WHERE THE DURATION OF THE IMPLEMENTATION FROM THE START OF THE AGENDA SETTING WAS VERY LONG

There are also examples of projects that have taken a long time or are still in progress: a weir on a Special Area of Conservation river took 10 years due to detailed discussions, getting designs and obtaining funding (Wales); A fish pass in the Włocławek dam did not function, which was diagnosed a long time ago but it was only reconstructed in 2014/15 (Poland); Removal of the Clondulane weir is after 6 years still ongoing due to refusal of the planning permission (Ireland); Removal of the weir Euteneuen on the river Sieg is discussed for 10 years due to lawsuits (Germany); Discussions to alter a barrier to provide migration passage has been ongoing for 5+ years (Northern Ireland); Demolition of Staicele's Dam in river Salaca has been negotiated for 20+ years between owners and public bodies, but without result (Latvia); Big projects with a large financial requirement in the National Transportation Plan take up to 12 years (Norway).

COULD YOU GIVE AN EXAMPLE ON HOW THIS TIME FRAME COULD BE SHORTENED, ESPECIALLY WHEN THE IMPLEMENTATION IS/HAS BEEN VERY TIME CONSUMING (>10 YEARS)?

Some recommendations are made on how this time frame could be shortened: Increasing public awareness of the benefits of project outcomes (Wales); careful selection and optimization of dam removal (Poland); change in legislation to compel owners to cooperate, change in funding systems and change in planning requirements (Ireland); increasing budgets provided by financial resources (Romania, Norway & Switzerland); early collection of data and using in-house expertise (Scotland); improving cooperation of governmental institutions and awareness raising of the issue (Estonia); improving the collaboration process by arranging meetings for all participants together (Sweden); carry out consultation with all interested parties and local communities at an early stage to find out what everyone would like for the river (France); reviewing indefinite permits by changing them to a defined timescale (Finland).

IS RESEARCH BEING CONDUCTED INTO THE VARIOUS OPTIONS THAT CAN BE USED TO RESTORE RIVER CONTINUITY IN YOUR COUNTRY?

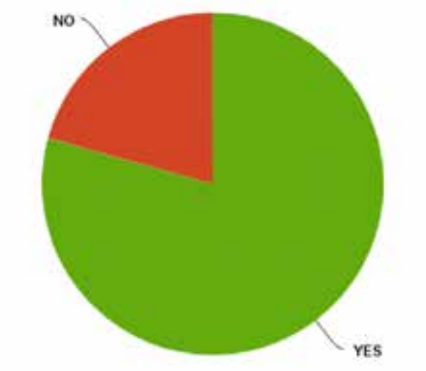


FIGURE 26

Distribution of the number of countries where research is (green) and is not (red) being conducted. (n=29).

Six countries (21%) out of the total of 29 are not dedicating research to the various options that can be used to restore river continuity (figure 26), namely Wales, North Macedonia, Russia, Hungary, Bosnia and Herzegovina and Cyprus.

COULD YOU GIVE AN EXAMPLE WITH AN ELABORATION?

Those that do, looked into river continuity to optimize barrier removal initiatives (Poland); inventoried the amount of dams lower than 15 metres and the feasibility to build a fish pass (Romania); modelled fish migration (Germany); placed cameras and fish counters to draw public attention and developed vislifts (The Netherlands); researched the effectiveness of fish passages and the effects of removing the Sindi Dam (Estonia); focused on technical solutions for up- and downstream passage of fish across existing barriers while maintaining production of electricity by hydropower-plants (Sweden); researched the effectiveness and cost-benefit relationships of physical habitat improvements in rivers (Norway); and monitored the fish density upstream of the barriers before and after restoring the river continuity (Denmark).

WHAT ARE THE BEST WAYS TO IMPROVE THE COMMUNICATION OF GOVERNMENTAL POLICIES REGARDING RIVER CONTINUITY RESTORATION TOWARDS THE PUBLIC?

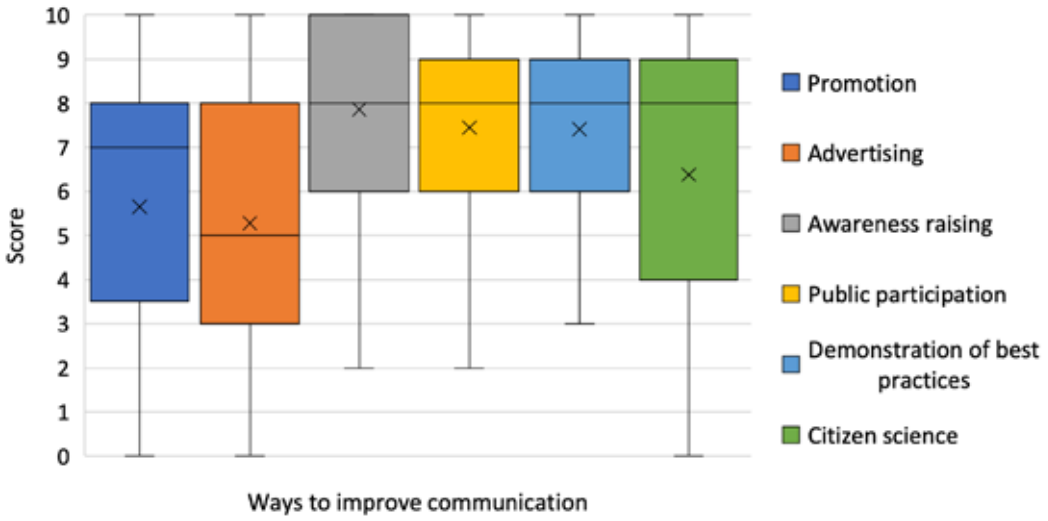


FIGURE 27

Boxplots of ways to improve the communication of governmental policies regarding river continuity restoration towards the public on a scale of 0 (not effective at all) to 10 (greatest impact). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values. (n=29).

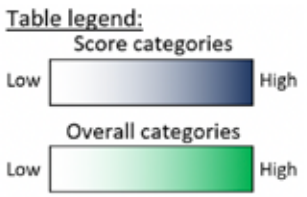
The best way for governments to communicate river continuity restoration policies towards the public is by awareness raising with a mean value of 7.9 (figure 27). This corresponds to literature on river management (Awoke, Beyene, Kloos, Goethals & Triest, 2016; Edelenbos, Van Buuren, Roth & Winnubst, 2017; Smits, Nienhuis & Saeijs, 2006) and was also concluded during the EU Green Week 2020 Brussels conference by the European Commission. It is striking, though, since from figure 25 it turned out that raising awareness is put to action less often than other actions to improve the quality and/or quality of river continuity restoration efforts. Apparently, the participating countries could overall use some help to raise awareness of the public around the issue of river continuity restoration.

Besides raising awareness, public participation and demonstration of best practices also score high (mean = 7.4), while citizen science, promotion and advertising have even been scored 0 a few times, meaning for a few countries these actions are not effective at all. Bosnia and Herzegovina scored all of the options with a 10. Again, these answers were very country-dependent, which is why an overview per country has also been listed in colour categories in table 9. From this table it becomes clear that Bosnia and Herzegovina, Spain, Lithuania, North Macedonia, Romania and England deem all the given ways as very useful to improve the communication of governmental policies regarding river continuity restoration towards the public. Russia, Portugal, Latvia, Hungary and Denmark seem a bit sceptical about implementing these actions to improve the communication. If they are open for it, these countries could perhaps receive some help to implement these actions in an effective and efficient way.

TABLE 9

Given answers to the question 'What are the best ways to improve the communication of governmental policies regarding river continuity restoration towards the public? Scale: 0 (not effective at all = low) to 10 (greatest impact = high)' by each country including the overall score of each country and way to improve communication.

	Awareness raising	*Public participation*	*Demonstration of best practices*	*Citizen science*	*Promotion*	*Advertising*	*Overall*
Bosnia and Herzegovina							
Spain							
Lithuania							
Republic of North Macedonia							
Romania							
England (UK)							
Finland							
Scotland (UK)							
Slovakia							
Malta							
Netherlands							
France							
Poland							
Ireland							
Estonia							
Sweden							
Cyprus							
Wales (UK)							
Switzerland							
Germany							
Northern Ireland (UK)							
Croatia							
Denmark							
Norway							
Hungary							
Austria							
Latvia							
Portugal							
Russia							
Overall							



WHAT ARE THE BEST WAYS TO AMPLIFY THE INFLUENCE OF NGOS ON THE GOVERNMENT TO IMPLEMENT POLICIES ON RIVER CONTINUITY RESTORATION?

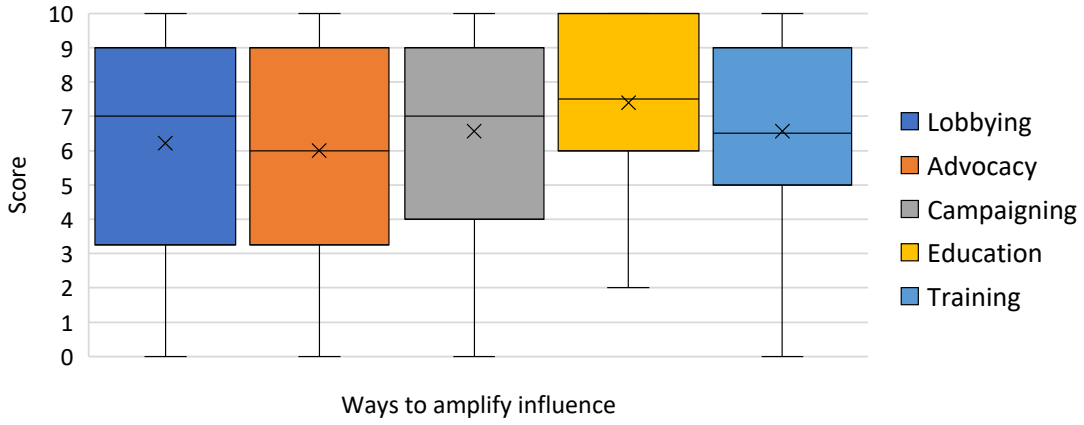


FIGURE 28

Boxplots of ways to amplify the influence of NGOs on the government to implement policies on river continuity restoration on a scale of 0 (not effective at all) to 10 (greatest impact). The coloured boxes indicate 50% of the scores that have been answered, while the crosses indicate the average values. (n=28).

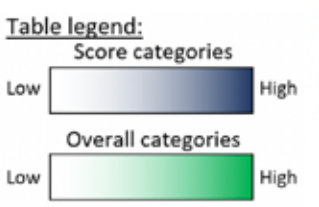
Every provided option of ways to amplify the influence of NGOs on the government to implement policies on river continuity restoration has been scored from 0 (not effective at all) to 10 (greatest impact). The option that is on average scored as the best way is education (mean = 7.4), but the difference with the other options is small with the lowest scored option (advocacy) with a mean value of 6.0 (figure 28). Three countries scored all options with the highest possible value (Ireland, Lithuania and France). An overview of the answers per country is given in colour categories in table 10.

Besides the three countries scoring all the listed actions with '10', North Macedonia, Wales, Romania and Spain also scored the actions very high, and therefore have the opinion that NGOs can influence the government to implement policies on river continuity restoration to a large extent (table 10). The countries that think otherwise are Malta, Portugal, Sweden, Russia, Northern Ireland, Norway, Hungary, Germany, Denmark and Latvia. However, Malta does think education can amplify this influence, but no other action can help achieve this in their opinion.

TABLE 10

Given answers to Q60 'What are the best ways to amplify the influence of NGOs on the government to implement policies on river continuity restoration? Scale: 0 (not effective at all = low) to 10 (greatest impact = high) by each country including the overall score of each country and way to amplify influence.

	Education	*Training*	*Campaigning*	*Lobbying*	*Advocacy*	*Overall*
Ireland						
Lithuania						
France						
Republic of North Macedonia						
Wales (UK)						
Romania						
Spain						
Slovakia						
England (UK)						
Finland						
Scotland (UK)						
Poland						
Cyprus						
Bosnia and Herzegovina						
Estonia						
Netherlands						
Croatia						
Switzerland						
Latvia						
Denmark						
Germany						
Hungary						
Norway						
Northern Ireland (UK)						
Russia						
Sweden						
Portugal						
Malta						
Overall						



DO YOU HAVE ANY COMMENTS OR SUGGESTIONS THAT HAVE NOT BEEN ADDRESSED IN THIS SURVEY?

Any links to national databases or national level reports, and references to publications or websites that substantiate the information that is given in the provided answers are used for ECRR's own overview, and are saved for future reference if necessary. They are not used as references in this report, as the participants who filled out the survey are our references in the case of the answers.

A few comments and suggestions are made in this very last question. For Bosnia and Herzegovina this regards the explanation of river continuity restoration not being addressed in national legislation. Only in RBMPs there are measures which envisage to develop a study to improve the hydromorphological characteristics of watercourses with river basins of more than 10 km2. The study should identify the key measures and locations where it is possible to: repair longitudinal continuity of the watercourse with construction of fish ladders, removing low barrier etc.; restore the natural river flow; improve environmental conditions in coastal areas; remove dams; reconnect rivers with floodplains and/or habitats of important plant and animal species. Activities on implementation of these measures have not yet been performed. From Ireland, we received the comment that weirs and structures are often precepted by the public as if they have always been there. It is very difficult to make them understand that these are man-made structures with negative impacts, not just on fish migration but on the functioning of the river system. Other comments and suggestions on the survey itself can be found in the discussion.

4. RESULTS CORRELATIONS

DO YOU HAVE ANY COMMENTS OR SUGGESTIONS THAT HAVE NOT BEEN ADDRESSED IN THIS SURVEY?

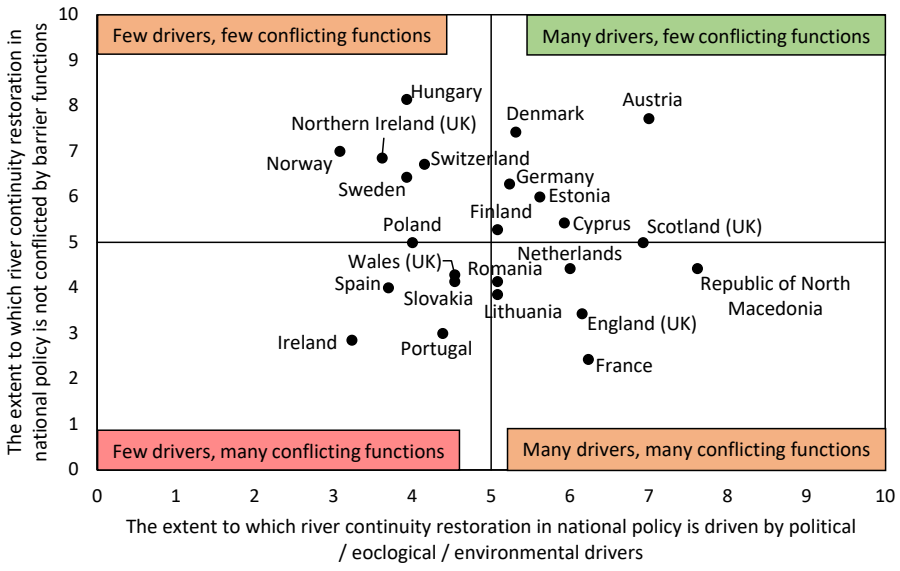


FIGURE 29

Four-quadrant matrix chart of the extent to which river continuity restoration in national policy is driven by political, ecological, and environmental drivers, and the extent to which barrier functions do not obstruct it. (n=24, r=-0.12).

There is no strong correlation between the amount of drivers and the level of obstruction (r = –0.12) when the mean scores per country from these answers are plotted against each other with the level of obstruction subtracted from 10, since obstruction negatively affects river continuity restoration (figure 29). We do see that seven countries (29%) fall in the category of countries with many drivers and few obstructions to river continuity restoration, meaning these countries theoretically have high potential when it comes to implementing measures in policies regarding river continuity restoration (Austria, Denmark, Germany, Estonia, Finland, Cyprus and Scotland). Five countries (21%) have few drivers and many conflictions to river continuity restoration. These countries (Ireland, Portugal, Slovakia, Spain and Wales) need attention when it comes to making river continuity restoration happen.

WAYS TO IMPROVE THE COMMUNICATION OF GOVERNMENTS TOWARDS THE PUBLIC & WAYS TO AMPLIFY THE INFLUENCE OF NGOS ON THE GOVERNMENT

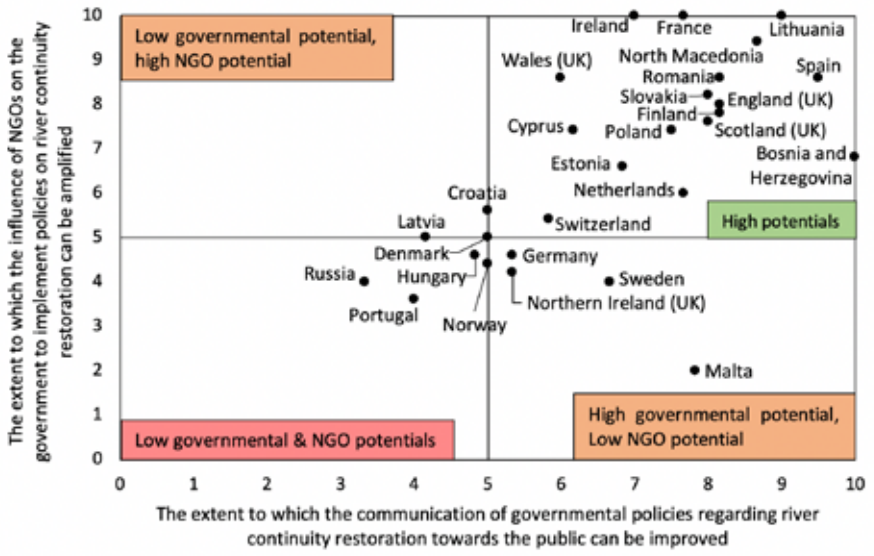


FIGURE 30

Four-quadrant matrix chart of the extent to which the communication of river continuity restoration policies towards the public can be improved, and the extent to which the influence of NGOs on the government to implement river continuity restoration policies can be amplified. (n=28, r=0.63).

The correlation between the potential of improving both the communication from governments towards the public and the influence of NGOs on governments is moderately strong with a correlation coefficient (r) of 0.63. In other words, the strength of the relationship between the two variables is moderate and 63% of the variation in one variable is related to the variation in the other.

Most of the countries (61%) scores both of the questions with high values, meaning both the NGOs as the governments have a similar amount of potential to implement and communicate river continuity restoration policies. Only four countries (14%) can be advised on the basis of figure 30, since Germany, Sweden, Northern Ireland and Malta have scored the governments high, while the NGOs are scored low in regards to their potential to communicate and implement river continuity restoration policies. For these countries the NGOs could use a little help to amplify their influence, so ultimately the overall communication regarding river management is improved.

10 Conclusions

The high number of 29 out of 49 contacted voluntarily participating European countries that cover more than 80% of the area and the comprehensive amount of country specific information provided prove a high interest in the topic of river continuity restoration. This allows for drawing a substantial number of general conclusions at the European level, and at the same time gives valuable insights in country specific situations. From this river continuity survey the following general conclusions can be drawn:

RECOGNITION OF RIVER CONTINUITY IN CURRENT NATIONAL POLICIES

- 80% of all participating countries have any form of national policy or strategy to restore river continuity, while the other 20% have broader and more comprehensive plans.
- The EU Water Framework Directive and fish migration improvement are the main drivers for river continuity restoration.
- Hydropower generation is the main function of barriers that conflicts with river continuity restoration, followed by flood protection.
- Industries and NGOs are the most influential stakeholder groups on river continuity restoration, followed by the public sector.
- The various functional uses of a barrier are on average for about 80% regulated by law and/or permits. This applies mostly to hydropower generation and flood protection, but hardly to recreation and cultural heritage.
- In case of a permit, in 40% of the countries there is no obligation to remove a barrier after the term of the permit has expired.
- River Basin Management Plans are prepared and used by almost every country for programming the implementation of river continuity restoration measures.
- Half of the countries has a priority list of barriers where river continuity should be improved. The barriers with the largest environmental/ecological impact have far most the highest priority. The prioritized barrier types are (in order of importance):
  1. *Those with the largest environmental/ecological impact*
  2. *Easy to implement (low hanging fruit)*
  3. *Any barrier lacking a (functioning) fish passage*
  4. *Obsolete barriers*
- The measures to restore river continuity that are currently applied to river barriers are (in order of the extent to which they are applied):
  1. *Adding a fish passage*
  2. *Constructing a bypass channel*
  3. *Barrier removal*
- River continuity is an issue that is rarely discussed in political discussions for most of the countries.
- Funding of river continuity restoration measures is mainly covered by national and European funds. Global funds (e.g. GEF) comprise only 1% of all available and used funds. With all the present financial instruments combined, on average 35% of the policy goals over the participating countries can theoretically be achieved.

The scope of restoring river continuity embraces more than solely improving connectivity for biota to migrate. It encompasses the flow of water, sediment and biota downstream and the possibility for biota to migrate upstream. Measures to improve river continuity range from technical fish migration facilities to entire dam removal addressing part or all of the environmental impacts caused by artificial barriers in rivers.

River continuity restoration is to a reasonable extent recognized in current national policies, but the speed of implementation should be substantially increased. This asks for broader and more comprehensive plans, where the implementation of the EU Biodiversity Strategy 2030 offers an excellent opportunity. In addition to the target of 25,000 kilometres of free-flowing rivers, targets could be set to construct fish passes and by-passes to improve at

least the passability for fish but also the habitat connectivity for other species. Moreover, environmental flows or sediment management are alternative solutions to mitigate the impact of manmade barriers in rivers.

As hydropower generation is the main function of barriers that conflicts river continuity restoration, the energy sector has a great responsibility in seeking alternatives and synergies to improve the river continuity. The European Green Deal is a plan to make the EU's economy sustainable by turning climate and environmental threats and challenges into opportunities and making the transition towards a climate neutral Europe by 2050 and just as inclusive for all. Technical assistance and support will from autumn 2021 on be provided by the EU, taking a wide range of issues into account, including hydropower generation, flood management, water supply, agriculture and navigability. Since industries and NGOs, followed by the public sector are most influential, river continuity restoration is an obvious Green Deal activity.

The legislation and licensing for the functional use of rivers and barriers should be adapted to comply more with the integrity, ecological functioning and biodiversity of the river systems. The Water Framework Directive and Integrated River Basin Management Planning are commonly used and can easily include river continuity restoration plans and measures. This means that national governments should emphasize on developing prioritization strategies supported by research, knowledge and best practice development. Prioritisation strategies are used in about half of the countries and aim to determine which barriers to tackle first to restore the river continuity. There is no overall prioritization in the measures that are applied to barriers. It would be easy if they were to be prioritized as a whole as some measures are more effective or efficient, but you cannot decide beforehand what should be done. This depends on the situation in the field and the characteristics of the river at that certain geographical place among other things. Funding the measures to restore river continuity is of course needed with the current main funders being the national governments and the EU. Political discussions are highly needed as the present funding is insufficient for the available ambitions and plans. This is where the European Commission should come in with the economic sectors, in particular those for hydropower generation and agriculture production, through the European Business for Biodiversity movement they are building together.

THE POTENTIAL OF RIVER CONTINUITY RESTORATION

- A national database of artificial river barriers is used by 70% of the countries. Most of them have the number of barriers registered for a greater part of the country, while a few know all of them.
- Not all numbers are necessary to adjust any policy accordingly. Knowing the quantity of the majority of dams is sufficient. However, if no information is known for a certain country, more effort should be put into finding out the right numbers to a sufficient extent.
- Of the total number of river barriers, 10% is already passable for fish or has a fish pass, while 50% can be adjusted to become passable.
- Of all barriers, 20% is thought to be obsolete, of which a third is believed to be removable (7% of the total). Barrier removal is a rather recent activity that gains momentum. A mere 1% has been removed so far.
- For 15% of the barriers there are plans that include hydromorphological and ecological restoration measures.
- 85% of the countries have expressed the ambition to contribute to the EU Biodiversity Strategy implementation. It has been indicated that much more can be done with low-cost actions through regular river maintenance and by barrier removals with smart resource allocations.

As in general 20% of the barriers appear to be obsolete, the potential for river continuity restoration is enormous. Therefore, knowing the exact numbers of dams in each country is not really essential to start developing national river continuity strategies, policies and plans. There are dams enough that could be removed when the plans are there and the funding is available. When having so many dams that can be removed, a prioritization approach becomes an essential prerequisite considering the limited resources. Important elements for prioritization are e.g.

what are the ecological gains when removing a specific dam, how easy or difficult is a barrier to remove, has a barrier a (working) fish pass or is it obsolete. The big question is how to balance these factors by developing criteria for selecting dam removals especially in case of restoring certain river basin districts or certain catchments or even entire basins. Strong guidance from any source of knowledge or know-how is highly needed and could come from research, knowledge institutes and platforms, best practices dissemination and demonstration.

RIVER CONTINUITY RESTORATION IMPORTANCE AND LOCAL OPPOSITION

- On average, the countries consider the importance of river continuity restoration as moderate (5.8).
- Most countries frequently face strong local conflict/opposition in relation to river continuity restoration projects ranging from 'sometimes' to 'with (nearly) every project' in 65% of the cases.
- The actions that are mostly used to improve the quality/quantity of river continuity restoration are:
  1. *Improving information and knowledge*
  2. *Legal enforcement and regulations*
  3. *Financial support*
- Research on river continuity restoration is being conducted in 80% of the countries.
- Governmental communication on river continuity restoration towards the public can be improved by:
  1. *Awareness raising*
  2. *Public participation*
  3. *Demonstration of best practices*
- The best ways to amplify the influence of NGOs on the government to implement policies on river continuity restoration are education, training and campaigning.

As the national governments consider the importance of river continuity restoration as fairly high, the current approach is rather top down with the national governments but also the NGOs being responsible for obtaining the funding of river restoration projects, guiding the formulation and implementation of RBMPs, public participation, and awareness raising. However, a bottom-up approach could be that obsolete barriers are locally immediately addressed by looking into the possibility to apply complete removal.

Right now there are no policy instruments or strategic incentives 'to pick low-hanging fruits' by implementing measures on barriers that currently are not used. An important aspect that requires attention is that there is quite often a strong local conflict/opposition to river continuity restoration. This can be improved by better governmental communication towards the public in terms of awareness raising, public participation, explaining the benefits and demonstration of best practice. This can be done together with NGOs. NGOs can amplify their influence to implement policies on river continuity restoration by education, training and campaigning. This would combine a top down with a bottom-up approach and thereby accelerate river continuity restoration over the full range from complete dam removal, environmental flows, sediment management strategies to nature-like and technical fish passes.

11 Considerations and recommendations

The response to the 62 questions produced a tremendous amount of information on this aspect of river management in Europe. It is clear that the 29 countries differ considerably in their starting points and individual goals. This complicates drawing specific conclusions and recommendations for all countries as well as individual countries. It is however possible to make recommendations for different target audiences to get more insight in how the results can be used in a broader context. This has been considered for three different target audiences: those who deal with policies and planning, the implementers, and lastly, researchers. These three groups are considered the most important stakeholders able to use the results of this river continuity survey to develop, improve or adapt policies, related planning and implementation schemes, prioritizing river restoration programmes and/or projects and developing criteria for the most suitable restoration measures. Finally, concrete and overall recommendations are given.

POLICYMAKERS & PLANNERS

The policymakers and planners are programme managers who are responsible for the strategic planning of the river restoration programmes and final plans to be implemented. Besides, NGOs and knowledge institutions or platforms are important for this category, as they are advocates and spokespersons to improve the naturalness of rivers and can also influence policies and strategies by their expertise.

Right now this river continuity survey has disclosed valuable information and general conclusions. While the conclusions are still rather general, they are also very concrete concerning the main directions towards an overall in quantity and quality improved and accelerated river continuity restoration. The next step should be for each country to consider their present approach regarding policy and planning and conclude which topics and items they could best emphasize on within their policy framework. Should this be on the policy in general or more specifically on certain aspects of river continuity restoration and/or the prioritization and/or river basin management planning and/or the funding and financial instruments and/or the potential for river continuity restoration and/or the barrier information and/or the perception of certain groups and so on. The synthesized information from other countries can be used for reflection or inspiration.

This can all be extracted from the survey results by comparing the own situation with the general conclusions and recommendations made. From this information a new or adapted strategy and policy can be derived. For instance, some countries declared to have already an overall strategy and policy in place, and it could be helpful to consult these countries in some way to see what their experiences are so far and what they are considering to improve or renew. Another approach could be to develop the strategy and policy in consultation with the whole group of countries that contributed to the survey. In that case it could be considered to arrange together special guidance and support.

By all means the exchange of information and (learning) experiences is crucial in this stage. Learning from others and discussing the options are recommendations that can even be made for the countries that did not participate in this survey. Commonly investigating the existing strategies with their objectives and ambitions, policies and prioritization and the existing guidance, instruments and tools for river continuity restoration can be very useful and thus helpful for both a better understanding and cooperation.

IMPLEMENTERS

Implementers of river continuity restoration projects are all stakeholders who contribute in any way to the actual execution of a certain project in practice. For this kind of practitioners, it is important to assess each project motivation and to try to involve the community to make a project highly effective. At the same time, they are faced

with the challenges of defining objectives and holistically understanding river ecosystems and the societal side of restoration. Overall, before carrying out river restoration projects, the drivers and strategies should be clear.

The implementers include for instance architects and engineers who design and construct measures to a man-made river barrier, municipal staff who are responsible for the judgement of a project, and – again – more local NGOs which in this respect can have a role in informing the public and other stakeholder groups on what is or should be happening and why. This is especially important as for this project, the survey and the reporting of its results have already been essential in awareness raising and initiating discussions around the subject of river continuity restoration. The participants have been stimulated to think about current policies, strategies, measures and possible actions to improve the overall outcome of European wide river continuity restoration.

As was confirmed by the survey results, awareness raising is important to increase common understanding of current affairs and the benefits and need to restore river continuity. Implementers are therefore recommended to increase the efforts in raising awareness locally among the general public, involve stakeholders from the start and showcase best practices. This can reduce or even prevent (local) opposition and support those who decide which projects and measures to fulfill or implement.

RESEARCHERS

Research groups should be invited and stimulated to make use of the opportunity of connecting their research to all aspects of river continuity restoration and river management in wider Europe. With their ability to investigate various background and implementation fields of both policymakers/planners and implementers, they can contribute to improving, expanding and verifying the river continuity restoration information, methodologies, measures and techniques that are currently available. Researchers, with complementary expert fields in river continuity restoration, nature management, environmental policy, European economics, or stakeholder participation can transdisciplinary and jointly investigate the scope and cross-compliance of policies and their implementation and the extent to which each European country is able to contribute to the requirements of the EU Water Framework Directive and its Biodiversity Strategy and the UN Sustainable Development Goals. When researchers are involved in the follow-up process, other target groups can be encouraged to be actively engaged in setting clearer goals, smoothening the ultimate process of river continuity restoration in pan-Europe.

SUPPORT, COLLABORATION AND COMMUNICATION

We have seen many changes in recent years: new tools and technologies have been developed; the scope of applied measures has widened; process-based restoration (e.g. through nature-based solutions) has been implemented more frequently; the awareness and recognition of river continuity as an issue has grown, and so have the expectations of politicians and the general public that the ecological status of rivers will improve through restoration; communication between stakeholder groups has become more effective. This last change plays an important role in the follow-up steps of this project. It is important to keep improving the communication between policymakers & planners, implementers, and researchers. Direct collaboration and involvement between these groups is necessary to further progress the science and application of river restoration.

This is where knowledge organizations and the civil society can combine forces to contribute on a social level by bringing people together and use their influence. They can reach out to the right people to participate in order to bring every aspect of the follow-up steps for an improved and accelerated river continuity restoration together to ensure the implementation of all actions and measures that have proven to be important right now. This will help to scale up and carry out river continuity restoration in Europe to its full potential to achieve the European-wide goals of sustainable development.

RECOMMENDATIONS

Overall

- Countries should have a national policy on river continuity restoration.
- Countries should have a prioritisation strategy for barrier removals.
- Prioritisation of applied measures for river continuity restoration has not been asked for in the survey. Although three types of main measures – adding fish passes, constructing barrier bypass channels and barrier removal – are in practice equally used, explorations for measure prioritisation approaches should be carried out.
- Countries should have a national database of the artificial barriers, but the usefulness and necessity of the completeness of such a database should not be overestimated.
- As there are huge opportunities for making barriers passable for fish (±50%) and obsolete dams that can be removed (±20%) and having plans for restoration measures available (±15%), national governments should have implementation programmes in place.

Policymakers & planners

- All countries should improve or develop the present approach regarding strategy, policy and planning of river continuity restoration.
- All countries can use the following outlines to check the status and development of the existing policy framework:
  a. *The barrier database*
  b. *The prioritisation of basins, catchments, waterbodies, and barriers*
  c. *Prioritization of one or more barrier removals in river basins, catchments, or waterbodies*
  d. *The country-specific available plans and measures to be used*
  e. *Funding and financial instruments*
  f. *Technical knowledge and expertise*
  g. *Technical guidance and support*
  h. *Monitoring and evaluation*
  i. *Public participation*
  j. *Awareness raising*
- Develop the strategy, policy and planning framework in consultation with the whole group of countries that contributed to the survey, considering arranging together special guidance and support.
- With all participating countries, commonly investigate the existing strategies and their objectives and ambitions concerning policies, planning, prioritisation, guidance, instruments and tools.

Implementers

- Before developing and implementing river continuity restoration programmes and projects, the drivers and strategies should be clear and used as starting points.
- Increase the efforts in raising awareness locally among the general public, involve stakeholders from the start and showcase best practices.

Researchers

- Contribute to improve, expand and verify the information, methodologies, techniques and measures that are currently available and could be developed.
- Jointly investigate the scope and cross-compliance of policies and their implementation and the extent whether countries are able to implement the requirements of their national policies and/or the EU Water Framework Directive. This can be done by testing and verifying the long term outcomes of the work and better integrating existing and new science into application on the ground. Furthermore, by monitoring baseline and changes, learning from implementation, providing the evidence on which to help change, and improving policy and decision making.

EU Policy

- Many of the conclusions and recommendations can be of direct help for national governments to implement the EU Biodiversity Strategy 2030 and the EU Green Deal serving the EU Climate Pact.

12 Reflection and feedback on the survey

The process of gathering the data and information by the survey went generally very smooth. Beneficial were the intensive preparation of the questions, the introduction and comprehensive literature summary to the subjects and the written motivation and instructions to the questionnaire. Furthermore, the process of designating people within the ECRR network to be the contact person for one or multiple countries and have the responsibility to have the survey filled out for this country/these countries showed to be very effective. While for the countries without a contact person, contacting various environmental ministries to reach the ultimate experts and senior officers on river management to fill out the survey resulted in highly reliable answers. Unfortunately, we did not manage to involve all European countries, but for the majority of these it was already expected that they would be too busy with defining and formulating upcoming policies and legislations to fill out the survey. All in all, the response rate was extremely high.

After the survey has been filled out by most of the countries, there was a meeting with almost all of the participants, so with everyone who contributed to the answers of the countries to the survey questions. In this interactive meeting the results and how to interpret them have been reflected upon and the questions and answer options have been evaluated by the participants. The discussions that have been conducted provided many useful insights on the given feedback on the survey as well as ideas on how the survey results and the ECRR can support other organizations to restore river continuity in the various countries. The way the questions from the survey have been asked and how they could have been improved has been clarified.

The coverage of the questions in the survey has turned out to be of great importance for the goal of this project, as they were all useful in obtaining a general overview of the current policies and strategic situation on river continuity restoration in Europe. Most of the questions have been answered, and together with the feedback from the participants, we now know that the great majority of the questions were well formulated and understandable and the information that was requested was feasible for the respondents to retrieve with the available information.

There have been more than sixty questions in the survey that provide us with an abundant amount of information, enabling to draw a challenging set of general conclusions. Besides, 29 different countries have answered them with each a different viewing point and with varying policies and regulations. There is no single country that stands above or below the other countries when it comes to the implementation of measures and realization of strategies regarding the restoration of river continuity. The countries differ in various aspects and reported or even had to synthesize their information differently.

As for the individual questions, it has been agreed upon that some of the questions were subject to interpretation of the respondents, as for instance measures on barriers and river basins are based on case by case information and possibilities. For some questions there are a few useful remarks, which we can learn from for a potential follow-up survey, or when a similar method is applied when trying to create an overview of information over multiple countries. This regards the following questions:

To what extent is river continuity restoration in national policy conflicted by the various barrier functions?
In the answer options, riverbed erosion reduction was not included as one of the functional uses of river barriers, while AMBER does mention it as a barrier function (AMBER, 2020).

To what extent do stakeholder groups influence the policies and/or strategies concerning river continuity restoration?
From this question it is not clear what kind of influence is meant. Not all the stakeholder groups that were listed assert positive influence, since for instance industries are most likely to negative affect river continuity by opposing dam removals in the case of the energy sector.

How are the functional uses of a barrier in your country regulated?

A functional use that is regulated by law does not exclude that is it regulated with the use of a permit. In the answers that were given as options, the respondents could only indicate either one, or none.

Are there any legal obligations to remove barriers once their permit ends?

This question is too general, since this can differ case by case. The same goes for a number of other questions too, as mentioned before, since most cases that are asked about are treated differently from each other for various reasons.

Which kind of barriers are prioritized for measures to improve the river continuity?

The categories in these answers are not 100% fitting, as there is some overlap. For instance, barriers with the highest ecological and environmental impact can be obsolete or small barriers, and the low hanging fruit also do not exclude the other answer options. However, the answers do clearly present the strategic priorities.

How often is river continuity mentioned as an issue in any political discussion in your country?

This question is not very informative, as it is unknown whether it is a good or a bad sign that river continuity is mentioned as an issue in a political discussion. No light has been shed on the nature of the mention of the issue.

What percentage of the total policy goal of your country can be achieved with all these financial instruments combined?

A few countries answered this question with 0 or 100%. These answers seem highly unlikely, as 0% would suggest that nothing can be done in this country when it comes to working towards a policy goal, even though none of the countries that did answer '0' indicated that there are no financial instruments available at all. On the other hand, when 100% of the policy goal can be achieved with the financial instruments, there should be no problem at all and the issue of river continuity restoration should in theory be easily solvable, though this is not the case in practice.

What is the total number of artificial barriers in your country? (including numbers on some barrier characteristics)

For these questions, there was the option to give the exactly known answer or an estimation. However, in the survey programme it was not possible to ensure that only one of those two were answered. So, for some countries we received both an exact number, as well as an estimation. This led to wonder whether the estimation indicated an additional number of barriers atop the known number, or whether this was an estimation of the total amount, including the known number. The estimations have been taken out when a number was already indicated at 'known'. Besides, the estimations had to be filled out in percentages of the total. This might have been confusing, as some answers exceeded 100. Perhaps for some answers, the number that was given was an exact number instead of a percentage, making the information not very reliable, as they might be incorrect. For table 7 the percentages were converted to exact numbers, based on the provided totals. In the future, it would be best if the respondents are to choose between one of the two options (either known or estimation) and are limited to only insert a single, exact number (no percentage). Lastly, the total number of barriers in a country partially depends on the size of the country and the number of kilometres of rivers. We did not ask about the density of the number of barriers per kilometre of river, so a comparison between the countries is made difficult using only the obtained data.

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