Biodiversity Strategy 2030

Barrier Removal for River Restoration

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Directorate-General for the Environment

2021

Biodiversity Strategy 2030

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Executive summary

The EU 2030 Biodiversity Strategy calls for greater efforts to restore freshwater ecosystems and the natural functions of rivers. Besides calling for better implementation of existing legislation on freshwater, the Biodiversity Strategy sets the target to make at least 25 000 km of rivers free-flowing again by 2030, by removing primarily obsolete barriers and restoring floodplains and wetlands. This document aims to support Member States and other actors involved in river restoration as they seek to achieve this target. The document seeks to clarify the terms and concepts of the target and its objectives, while recognising the need for such definitions to be translated into operational terms. It also provides general principles, and examples of existing approaches and methods that could be used to select and prioritise barriers that would need to be removed in order to reach the target of at least 25 000 km of free-flowing rivers in the EU. Finally, the document sets out an overview of the different EU funding mechanisms that could support river restoration projects.

The notion of 'free-flowing rivers' is not defined in the existing EU environmental legislation. Based on scientific definitions available, the Commission interprets 'free-flowing rivers' to mean rivers or other surface water bodies (e.g. lakes) that are not impaired by artificial barriers and not disconnected from their floodplain. Given the characteristics of Europe's river network, the high population density in some areas and the multiple demands on EU waters for different services, it would be very difficult to remove artificial obstacles along a river's entire course. This would also likely be incompatible with the maintenance of important river uses. The Commission thus intends to focus on stretches of rivers that can be restored to a free-flowing state, for the benefit of related habitats and species.

While in scientific terms full connectivity of a river system has four dimensions (longitudinal, lateral, vertical and temporal), the Commission proposes to focus efforts on barriers to longitudinal and lateral connectivity of river systems, as more experience and knowledge is available on these two dimensions. Furthermore, the Biodiversity Strategy calls for a focus primarily on '*obsolete barriers',* namely barriers that no longer fulfil their original purpose or are no longer needed. As regards the restoration of floodplains and wetlands, other complementary measures should be envisaged besides restoring lateral connectivity through the removal of artificial barriers. Such complementary measures could include, for example, re-meandering, restoration of oxbow lakes and restoration of riparian vegetation.

Altogether, the target of restoring rivers to a free-flowing state is designed to support and find synergies between efforts to achieve the Water Framework Directive objectives and the EU Birds and habitats Directives, with the overarching aim of boosting the restoration of freshwater ecosystems.

To combine the need for urgent action towards the 2030 target with a pragmatic and systematic approach, the document calls for efforts to be undertaken (or continue to be undertaken) to remove artificial barriers, wherever such opportunities exist, on the basis of current knowledge and experience. In parallel, it is necessary to develop a set of harmonised criteria, according to which river stretches could be defined as free-flowing and thus count towards the 2030 goal. This could be the subject of a joint process in which the Commission and the Member States work to achieve a harmonised approach at EU level.

Many restoration projects have already been implemented or are ongoing, and a number of existing methodologies can help prioritise sites in each Member State with a view to reaching the target. The document provides an overview of these methods and sets out some general principles for such prioritisation. These include the need to seek synergies with existing legislation or strategies, including with those applicable to protected areas and migratory species' migration routes (e.g. in connection with the Eel Regulation and the Pan-European

Action Plan for Sturgeons). They also include the need to consider existing uses, maximising co-benefits and avoiding as much as possible significant adverse effects on sustainable uses. Furthermore, good prioritisation and planning of action require robust data. In this context, actions to fill gaps in knowledge (e.g. on barriers' mapping) can be undertaken in parallel, to support not only the achievement of the Biodiversity Strategy's target but also a better implementation of EU legislation in general.

The document also provides an overview of the main EU funding instruments that can support river restoration projects. Member States are encouraged to consider such funding sources when planning for river restoration. They are also encouraged to integrate water-related objectives into relevant sectoral planning instruments (e.g. European Maritime Fisheries and Aquaculture Fund national programmes, CAP plans) to ensure appropriate financing for river restoration projects.

1. Purpose and scope of this document

1.1. Background

The EU Biodiversity Strategy for 2030[1] (hereinafter 'Biodiversity Strategy') aims at putting Europe's biodiversity on the path to recovery by 2030, with a view to ensuring that by 2050 all of the world's ecosystems are restored, resilient, and adequately protected. The Biodiversity Strategy addresses the main drivers of biodiversity loss, and seeks to foster action on the ground, with the involvement not only of local, regional, national and European authorities, but also of the general public, businesses, social partners and the research and knowledge community.

One objective of the Biodiversity Strategy is the restoration of freshwater ecosystems.

The existing EU legal framework on freshwater is ambitious and fit for purpose but implementation is lagging behind and enforcement must be stepped up. Recognising this, the Biodiversity Strategy calls for greater efforts to restore freshwater ecosystems and the natural functions of rivers. This can be achieved by removing or adjusting river barriers that prevent the passage of migrating fish and by improving the flow of water and sediments. This is to support the achievement of the objectives of the Water Framework Directive (WFD, 2000/60/EC). In addition, and to support the restoration of the natural functions of rivers, the Biodiversity Strategy sets a target to restore by 2030 at least 25 000 km of rivers into free-flowing rivers by 2030 through the removal of primarily obsolete barriers and the restoration of floodplains and wetlands.

The Commission committed to provide support to the Member States by 2021. The purpose of this document is to assist Member States in devising strategies to identify and prioritise obstacles that could be removed with the aim of achieving the highest environmental benefits, in a cost-effective fashion, and in identifying possible funding sources.

This document aims to clarify the Commission's interpretation of the Biodiversity Strategy's targets. It seeks to clarify, insofar as possible, the concept of free-flowing rivers and to develop a common understanding of how this target is linked to the WFD objectives, and to the Birds and Habitats Directives (the EU Nature Directives)[2], taking the Biodiversity Strategy's targets into account in river basin management planning and management of protected areas. It also offers an overview of existing methods that could be adapted and used to support the identification and prioritisation of sites where barriers could be removed to restore, insofar as possible, river connectivity, their wetlands and floodplains so as to contribute to the achievement of the Biodiversity Strategy's targets. Furthermore, the document provides an overview of existing EU financing tools that could be used to fund the removal of barriers and the restoration of floodplains and wetlands.

The target of restoring at least 25 000 km of rivers to free-flowing state is a target to be reached overall for the EU. All Member States are expected to contribute towards reaching this goal, to an extent that is proportionate to the types and characteristics of the rivers on their territory, taking into account other legitimate uses of water courses and related interests. This document does not intend to assign a share of the efforts by Member State, but rather to support them in analysing the potential for nature (and river) restoration in their territory.

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[1] COM(2020) 380 final [EU Biodiversity Strategy for 2030 Bringing nature back into our lives]

[2] Directive 2009/147/EC on the conservation of wild birds and Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora

Finally, this document does not replace – but gives additional support to – existing methodological guidance documents prepared in the Common Implementation Strategy of the Water Framework Directive, and guidance documents that support implementation of the EU Nature Directives and the management of Natura 2000 areas.

1.2. EU Biodiversity Strategy for 2030 – targets

The Biodiversity Strategy calls for greater efforts to restore freshwater ecosystems and the natural functions of rivers. It also calls for stepping up efforts to achieve the WFD objective of good ecological status. It mentions in particular the need to remove or adjust barriers that prevent the passage of migrating fish (and other organisms such as benthic invertebrates) and improving the flow of water and sediments: these are legal obligations to be met by 2027 for all EU waters.

The Biodiversity Strategy, however, goes further to foster a greater integration of efforts to achieve not only the WFD objective of achieving good ecological status, but also the objective of habitat and species restoration. It sets a target to restore at least 25 000 km of rivers into a free-flowing state, through two main types of action: removal of barriers; and the restoration of floodplains and wetlands.

This target, therefore, must be read as going beyond what is already required by the WFD in terms of good ecological status, in specific locations. It aims in particular at contributing to nature protection and the restoration of ecosystems, so as to achieve the Biodiversity Strategy objective that, by 2050, all ecosystems are restored, resilient and adequately protected. The Commission is of the view that the Biodiversity Strategy's twin focus on removing barriers and restoring floodplains and wetlands points at a concept that goes beyond the removal of transversal barriers.

The 25 000 km of free-flowing rivers is intuitively easy to understand: it suggests rivers (and lakes) in a natural state, undisturbed in their natural functions, unhindered by artificial barriers. However, there is no established consensus as to what criteria would define a free-flowing river that could count towards the EU target. Similarly, a ready-to-use indicator to measure free-flowing rivers currently does not exist. The following sections will elaborate on these concepts. The aim is to contribute to the current dialogue on nature restoration, and biodiversity protection, and their links to hydromorphology, and to offer support to Member States in devising their plans to contribute to the EU biodiversity targets.

1.3. Interplay with existing legislation

This section aims to clarify how the river restoration targets of the Biodiversity Strategy and the concept of free-flowing rivers relate to the WFD and the EU nature legislation. It illustrates how the river restoration target for free-flowing rivers addresses a key pressure in the context of the WFD (river fragmentation) and the importance to embed river restoration measures in the broader river basin management planning. It also illustrates how the twin approach set out by the Biodiversity Strategy (barrier removal and floodplain restoration) helps meet the objectives of the EU Nature Directives, for the recovery of protected species and habitats, and of any other habitat or species listed in other relevant EU legislation, whose functions and life cycles are dependent on rivers and their floodplains.

1.3.1. Water Framework Directive ecological status and river continuity

The overall purpose of the WFD is to establish a framework for the protection and management of inland surface waters, transitional waters, coastal waters and groundwater. The WFD requires Member States to protect, enhance and restore all water bodies to achieve good status, or good potential, by 2015, with limited possibilities to extend that deadline until 2027. When it comes to surface water bodies, status is defined in terms of ecological and chemical status.

The WFD defines ecological status as ‘an expression of the quality of the structure and functioning of aquatic ecosystems’. Ecological status is further specified in Annex V of the WFD, with a set of quality elements to be used as indicators to classify high, good and moderate status. For river water bodies, these include, besides biological quality elements[3] and physicochemical supporting quality elements[4], hydromorphological supporting quality elements, namely: hydrological regime; river continuity; and morphological conditions.

The hydromorphological supporting quality elements are expressly defined for assigning a river water body to ‘**high’ ecological status**, and directly refer to totally – or nearly totally – undisturbed conditions. When it comes to river continuity in particular, the high status definition explicitly refers to the absence of anthropogenic activities and to the undisturbed migration of aquatic organisms and sediments. This definition broadly corresponds to what could be generally understood as a free-flowing river.

The WFD does not require the achievement of high ecological status, but rather of good ecological status. The hydromorphological supporting quality elements are not expressly defined for assigning a river water body to **‘good’ ecological status**, but refer rather to the fact that the biological quality elements should deviate only slightly from the reference conditions. When it comes to hydromorphological quality elements, the WFD requires that the water body be in a condition that is consistent with the achievement of slightly impacted biological values. The hydromorphological supporting quality element conditions at high status are a key factor determining the reference conditions for the biological quality elements.

In short, for a water body to be classified as in good ecological status, its hydromorphological condition must be such that the biological quality elements deviate only slightly from reference conditions that are derived from high status conditions. This implies the removal of all barriers that hinder the possibility for the river to achieve good status.

However, barriers may in some cases be compatible with good status. This is so if biological quality elements sensitive to continuity in water bodies anywhere upstream or downstream of the barrier are only slightly affected, if necessary after applying adaptation and mitigation measures such as fish passes. It should be noted though that this assessment can only be valid if based on a biological assessment that is complete (WFD Annex V) and reflects well all hydromorphological pressures. In practice, such an assessment, and the correct identification of the required hydromorphological conditions necessary to achieve good ecological status, is complex and requires the use of biological assessment methods that are sensitive to the relevant hydromorphological pressures. In practice, this might not always be the case and the use of inappropriate or incomplete methods could result in the impact of certain barriers remaining undetected. As a consequence, it is possible that barriers are not removed in locations where their removal would be necessary to achieve good status.

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[3] Phytoplankton, macrophytes and phytobenthos, benthic invertebrate fauna, fish fauna.

[4] Thermal conditions, oxygenation conditions, salinity, acidification status, nutrient conditions, specific pollutants.

Moreover, the WFD also recognises the need to maintain some barriers that serve specific purposes (Article 4(3)), including in particular inland navigation, flood defence, electricity generation or agriculture. If certain conditions are fulfilled, the concerned water bodies can be designated as 'heavily modified water bodies', and the alternative objective of 'good ecological potential' is set, which requires achieving a condition that is close to the "best approximation to ecological continuum"[5]. For these water bodies, it is not legally required to remove barriers, but it is mandatory to put in place mitigation measures to restore continuity as much as possible. Typical measures will include bypasses for fish and sediment, fish ladders, adaptation of the operation of infrastructures, in particular to ensure ecological flows, installations to prevent fish mortality, and similar measures[6].

To summarise, the WFD requires continuity for all EU river water bodies insofar as necessary to support the achievement of good ecological status, but not necessarily the complete absence of barriers.

1.3.2. Floodplains and wetlands

River basins consist not only of surface and groundwater bodies but also include terrestrial ecosystems, wetlands, and floodplains that are closely connected.

Floodplains, as defined in a recent report by the European Environment Agency (2019)[7], are river banks and the areas next to rivers that are covered by water only during floods. They are part of the river system and act as the interface between the catchment and the river. In their natural condition, floodplains are an important ecological part of the river system and provide many valuable ecosystem services: they filter and store water, store carbon, ensure both natural flood protection and the healthy functioning of river ecosystems, and help sustain the high biological diversity present in these systems.

As part of the river system, floodplains are relevant to the WFD: the structure and condition of the riparian zones, which are part of the floodplain area, are explicitly included in the definition of the hydromorphological supporting quality elements. Furthermore, the notion of 'ecological status' includes certain organism groups that depend on the lateral connectivity between the river and its floodplain, e.g. aquatic insects, such as dragonflies, or certain species of fish, such as the bitterling, *Rhodeus amarus*.

When it comes to wetlands, the WFD purpose includes the protection of terrestrial ecosystems and wetlands directly dependent on the aquatic ecosystems. When it comes to groundwater, the WFD identifies the use of wetland functions as a possible means of achieving its groundwater objectives[8], which include obligations for (aquatic and terrestrial) ecosystems[9]. However, the WFD does not set specific obligations or ecological objectives for wetlands, other than where those wetlands, or parts of them, are part of a water body[10]. Furthermore, the

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[5] For more details see WFD CIS Guidance Document No. 37 'Steps for defining and assessing ecological potential for improving comparability of Heavily Modified Water Bodies'.

[6] For more information, see the results of the FITHydro project FIThydro - Fishfriendly Innovative Technologies for Hydropower - https://www.fithydro.eu/

[7] Floodplains: a natural system to preserve and restore — European Environment Agency (europa.eu)

[8] Included in the list of supplementary measures in WFD Annex VI.B(vii).

[9] Indeed, the definitions of good groundwater quantitative status and good groundwater chemical status include a requirement for, respectively, the levels of groundwater or the concentration of pollutants therein to be such so as not to result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters (which include the objectives for Protected Areas under the Natura 2000 Directives) or in any significant damage to terrestrial ecosystems which depend directly on the groundwater body.

[10] WFD CIS Guidance Document No. 2 – 'Identification of Water Bodies. This Guidance makes it clear that those wetlands must be associated with a 'water body', and must directly influence the status of the related 'water body' (i.e. the structure and condition of such wetlands are relevant to the achievement of the objectives for a surface water body).

Guidance document on wetlands[11] identifies cases in which the WFD may (in part) apply to wetlands.

Floodplains and wetlands are also addressed by the provisions of the Birds and Habitats Directives[12]. The overall objective of these directives is to ensure that the species and habitat types they protect are maintained, or restored, to a favourable conservation status throughout their natural range within the EU. It is therefore more than just halting their further decline or disappearance; the aim is to ensure that the species and habitats recover sufficiently to enable them to flourish over the long term.

Among the species and habitats that are protected under the Birds and Habitats Directive, there are several freshwater ones, but also terrestrial species and habitats that occur on the floodplains of rivers and that depend on a functioning river system to thrive. The re-establishment of the natural functions of a river and its connection with its floodplain are often essential to enable those habitats or species, greatly dependent on their associated water courses, reaching favourable conservation status[13].

A selection of key habitat types in Annex I of the Habitats Directive covering rivers, lakes and associated floodplain habitats, strongly dependent on the connectivity of the river system, is listed, for illustration purposes, in Table 1 below.

Table 1 – River, lake and alluvial Annex I habitat types (source EEA, 2020)

Rivers and lakes (20 types)		**Rivers and lakes (cont.)**	
3110	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)	3280	Constantly flowing Mediterranean rivers with *Paspalo-Agrostidion* species and hanging curtains of *Salix* and *Populus alba*
3120	Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean, with *Isoetes* spp.	3290	Intermittently flowing Mediterranean rivers of the *Paspalo-Agrostidion*
3130	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*	32A0	Tufa cascades of karstic rivers of the Dinaric Alps
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	**Alluvial meadows (4 types)**	
3150	Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* — type vegetation	6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels
3160	Natural dystrophic lakes and ponds	6440	Alluvial meadows of river valleys of the *Cnidion dubii*
3170	Mediterranean temporary ponds	6450	Northern boreal alluvial meadows
3180	Turloughs	6540	Sub-Mediterranean grasslands of the *Molinio-Hordeion secalini*
3190	Lakes of gypsum karst	**Alluvial/Riparian forests (8 types)**	
31A0	Transylvanian hot-spring lotus beds	9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*
3210	Fennoscandian natural rivers	91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)

[11] CIS Guidance Document No. 12 'The role of wetlands in the Water Framework Directive'.

[12] Directive 2009/147/EC and Directive 92/43/EEC.

[13] ETC/ICM Technical report 5/2020 – Preliminary assessment of river floodplain condition in Europe.

3220	Alpine rivers and the herbaceous vegetation along their banks	91F0	Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *U. minor*, *Fraxinus excelsior* or *F. angustifolia*, along the great rivers (*Ulmenion minoris*)
3230	Alpine rivers and their ligneous vegetation with *Myricaria germanica*	92A0	Salix alba and *Populus alba* galleries
3240	Alpine rivers and their ligneous vegetation with *Salix elaeagnos*	92B0	Riparian formations on intermittent Mediterranean water courses with *Rhododendron ponticum*, *Salix* and others
3250	Constantly flowing Mediterranean rivers with *Glaucium flavum*	92C0	Platanus orientalis and Liquidambar orientalis woods (*Platanion orientalis*)
3260	Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation	92D0	Southern riparian galleries and thickets (*Nerio-Tamaricetea* and Securinegion tinctoriae)
3270	Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation		

1.3.3. The twin approach of the Biodiversity Strategy

As illustrated in the sections above, EU legislation exists for the protection of water, habitats and species. Nevertheless, the EU water bodies and the habitats and species protected by EU legislation continue to be under pressure.

When it comes to surface water bodies, the most common pressures are hydromorphological and are reported to affect 34 % of water bodies, according to the WFD assessment[14]. These pressures include physical alterations of the channel, bed, riparian area or shore; dams, barriers and locks; and hydrological alterations. As for the river, lakes and alluvial and riparian habitats protected by the EU nature legislation, only 17% have a good conservation status, with modifications of hydrology and hydromorphology (including, for example, drainage, water abstractions, and dams and reservoirs) reported as among the top pressures.

These data clearly underline the need to focus on hydromorphological types of pressures for the achievement of the WFD and EU nature legislation objectives. The data also explain the Biodiversity Strategy's proposed twin approach to reaching the minimum 25 000 km target: by removing barriers; and by restoring floodplains and wetlands. This is why the Commission considers that the concept of free-flowing rivers – to be achieved through barrier removal and the restoration of floodplains and wetlands – translates into a complete absence of artificial barriers and the reinstatement of the natural, multidimensional connectivity of a river.

In fact, river continuity is already a key aspect of good ecological status. Removal or adaptation of barriers is part of the measures necessary to fulfil the legal obligations under the WFD. River continuity is necessary also to achieve the objectives of other EU legislation. For example, the Habitats Directive protects the European sea sturgeon *Acipenser sturio*, which needs to migrate between the sea and freshwater. The European eel, protected by the Eel Regulation[15], also needs river continuity to survive. It should further be noted that the WFD, under Article 4 (1)(c), also includes the obligation to achieve the objectives for 'protected areas', which include those set under the Habitats Directive.

However, many habitats and species - in particular wetland and floodplain ones – need more than longitudinal continuity to thrive: they directly depend on the natural connectivity within a river system, including the lateral one.

[14] WISE-Freshwater WFD visualisation tool) https://www.eea.europa.eu/themes/water/european-waters/water-quality-and-water-assessment/water-assessments

[15] Council Regulation (EC) No 1100/2007 establishing measures for the recovery of the stock of European eel.

Hence, the aim of the Biodiversity Strategy when it comes to freshwater ecosystems is to be understood as going beyond the concept of continuity of the WFD, which does not necessarily require barriers to be removed. It is to focus on the overall connectivity of the river system, intended as free from artificial barriers, including in its lateral dimension.

Restoring rivers to free-flowing state is designed not only to support and foster the achievement of the WFD objectives, but also to boost broader river restoration efforts, for the benefit of habitats and species.

2. Understanding the Biodiversity Strategy terms

This document proposes a set of definitions to clarify the overall concept of free-flowing rivers. It also recognises the need for such definitions to be translated into operational terms, fit for the European context, so as to promote, rather than stifle, river restoration actions.

2.1. Definitions

The first step towards pursuing the target of at least 25 000 km of free-flowing rivers, through the removal of primarily obsolete barriers and the restoration of floodplains and wetlands, consists of defining a free-flowing river. It is also necessary to define the other essential elements of the target, namely what is considered a barrier, and what is meant by restoring floodplains and wetlands.

Free-flowing river

While there is no established definition of what could be considered a free-flowing river, this document proposes as a starting point a general and wide definition in agreement with those already proposed in literature (Belletti *et al*., 2020; Fryirs, 2013; Grill *et al.*, 2019; Wohl *et al*., 2019).

It is proposed to define a *free-flowing river* as one that supports connectivity of water, sediment, nutrients, matter and organisms within the river system and with surrounding landscapes, in all of the following four dimensions (see Figure 1):

1. longitudinal (connectivity between up- and downstream);
2. lateral (connectivity to floodplain and riparian areas);
3. vertical (connectivity to groundwater and atmosphere); and
4. temporal (connectivity based on seasonality of fluxes).

A free-flowing river is not impaired by anthropogenic barriers and is not disconnected from its floodplain when a floodplain is present[16].

[16] In some cases, due to natural constraints, a floodplain is not naturally present, e.g. in a gorge or canyon. Many headwater stretches do not have a floodplain either.

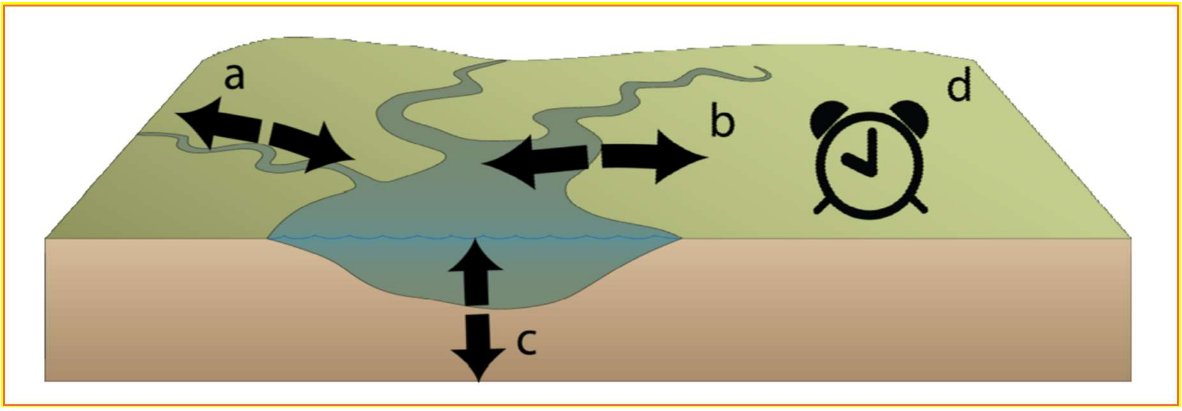


Figure 1 Four dimensions of connectivity within lotic ecosystems (after Ward 1989): a) longitudinal connectivity (channel ←→ channel); b) lateral connectivity (channel ←→ floodplain); c) vertical connectivity (channel ←→ groundwater); and d) temporal connectivity (across time) (from MacDonough et al., 2011). [Modified from symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science]

It is to be noted, however, that river connectivity in each river system is shaped by specific climatic and geological contexts and by the legacy of geomorphological and ecological processes. In some contexts, free-flowing rivers can be naturally impaired by woody debris, geological structures (e.g. valley confinement) and natural obstacles (e.g. waterfalls, beaver dams). Such natural impediments are not to be considered barriers in the context of the Biodiversity Strategy (see definition of barriers below).

Barriers

AMBER, an EU funded research project, has carried out extensive work on river barriers[17]. For the purpose of this document, the AMBER definition of barriers is used: these are physical artificial barriers of any type or height that are likely to have an impact on river ecosystem connectivity (including water, sediment, nutrients/matter and organisms).

The AMBER project focused on transversal barriers, i.e. barriers to longitudinal connectivity. It has classified this barrier type into six main functional groups that capture variation in size and use: dam, weir, sluice, ramp/bed sill, ford and culvert, plus ‘other’ (e.g. groynes and spillways).

However, the definition of free-flowing rivers above refers to multidimensional connectivity. A mere focus on longitudinal connectivity would significantly reduce the scope of the Biodiversity Strategy, which clearly refers to the ‘restoration of floodplains and wetlands’. This points at the need to focus, besides longitudinal connectivity, at least also on the lateral one, between the river and its riparian area and floodplain. See Box 1.

Artificial barriers exist that interrupt lateral connectivity such as bank protection works (e.g. revetment, rip-rap), embankments, levees and flood protection dykes, which should be considered for removal to contribute to the target of at least 25 000 km of free-flowing rivers. Unlike the barriers to longitudinal connectivity under the AMBER project, artificial barriers to lateral connectivity are yet to be classified in agreed categories.

Finally, the Biodiversity Strategy calls for a focus primarily on ‘*obsolete barriers’.* This term refers to barriers that no longer fulfil their original purpose or that are no longer needed[18]. This could be, for example, a dam that is no longer useful for hydropower generation, water supply or flood protection, or a weir that no longer acts as a river bed stabiliser because it is damaged

[17] AMBER – Adaptive Management of Barriers in European Rivers - https://amber.international/

[18] The assessment of whether a dam is deemed to be obsolete has to be done via a case by case assessment taking into consideration the specific purpose and all local, regional and national particularities.

or because the river has changed its geomorphological configuration and such infrastructure is no longer useful. When prioritising barriers for their possible removal, it will indeed be important to evaluate the role they might still be playing (although in this case the possible benefits of such future use needs to be assessed against the benefits of removing it for the sake of nature restoration), or the otherwise beneficial effect that such barriers may have (e.g. for biodiversity). This is to take into account the need to maintain different important uses such as inland navigation[19], renewable energy generation[20] or agriculture and the wider environment. The WFD already integrates provisions for such uses and sets rules to ensure the integration of different objectives.

Restoration of floodplains and wetlands

The Biodiversity Strategy mentions the restoration of floodplains and wetlands as a means to achieve free-flowing rivers, thereby referring to the lateral connection between a river and the adjacent area.

Rivers and their adjacent floodplains are very dynamic ecosystems, closely linked through flooding, lateral exchange of sediments[21], wood, nutrients, groundwater exchange and organism fluxes – see Figure 2. For the purpose of this document, the restoration of free-flowing rivers, floodplains and wetlands can thus be understood as:

1. the removal of artificial structures affecting the free-flowing character of water, sediment, nutrients, matter and organisms along river systems;
2. the rehabilitation of hydrological, morphological and biological connectivity between wetlands, floodplains and their river channels; and
3. the recovery of fluvial processes in general, which are necessary to support a healthy freshwater ecosystem.

It is clear that the reestablishment of connectivity through barrier removal is in many cases the necessary condition, but not sufficient, for the proper restoration of floodplains. Several additional measures are usually needed to complement the removal of infrastructure: e.g. re-meandering, and restoration of oxbow lakes, restoration of riparian vegetation, to mention but a few.

BOX 1 - Definition of lateral connectivity and link to free-flowing rivers in the context of the Biodiversity Strategy

Lateral river connectivity is defined as the movement of water, sediments, nutrients, matter and organisms from the river into the floodplain and vice versa. Pathways include overbank flows and side channel flows (i.e. lateral connectivity *sensu stricto*) and underflows (or hyporheic flows = vertical connectivity). The most prominent phenomenon related to lateral connectivity is the inundation of the floodplain when the river discharge exceeds the capacity of the main channel and flows overbank. Side-channel flows and underflows are also relevant aspects of lateral river connectivity. Lateral river dynamics driven by bank erosion represent a further important aspect of lateral river connectivity, allowing the active channel to migrate within the floodplain ('erodible corridor concept', Piégay *et al*. 2005).

[19] See. Sustainable and Smart Mobility Strategy – putting European transport on track for the future COM(2020)789 final; NAIADES III: Boosting future-proof European inland waterway transport

[20] Renewable energy directive | Energy (europa.eu)

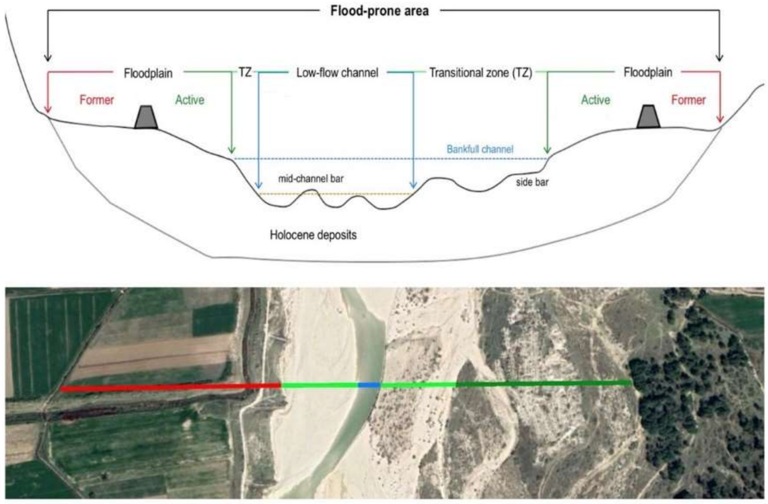
[21] For more information see the Common Implementation Strategy work on sediment (CIS guidance document under preparation at the time of publication of this document): https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm

Lateral river connectivity manifests itself in specific habitat features ('structural connectivity') and the presence of habitat-specific biota ('functional connectivity') in the floodplain. Human-induced loss of lateral river connectivity results in alterations of these features from the natural conditions. Quantifying lateral river connectivity can thus be based on assessing the presence of artificial structures (e.g. embankments, drainage) altering the naturally occurring lateral connectivity (i.e. pressure indicators); floodplain-specific habitat structures and processes (i.e. state indicators); or the presence of floodplain habitat-specific biota (i.e. state and impact indicators).

'Free-flowing' in relation to lateral connectivity

The lateral connectivity of free-flowing rivers allows for movement of water, sediments, nutrients, matter and organisms into and from the floodplain that is neither constrained nor altered by artificial structures (e.g. channelisation, embankment, drainage). In free-flowing rivers the river channel can migrate freely within the floodplain (if not constrained naturally), and the lateral connectivity of free-flowing rivers is not impaired by channel bed incision. The floodplains of free-flowing rivers feature a mosaic of typical habitats (e.g. wetlands, oxbow lakes, sand or gravel bars) and biota. The manifestation of lateral connectivity at free-flowing rivers differs naturally between river or floodplain types.

When a river is free-flowing, the extent of the active floodplain (i.e. area inundated at high flows) corresponds to the potential flood-prone area. This means, firstly, that no structural barriers (at channel bed and banks, in the floodplain) or floodplain drainage are in place. Secondly, the river flow regime follows a natural hydrological pattern that includes natural frequency, magnitude, and duration of floods.



Source: Bottom image: Google Maps (2020)

Figure 2 - Schematic cross-section (top) and example (bottom) of the flood-prone area including parts of the low-flow channel (blue), bank-full channel only wetted at river discharges above low- flow (transitional zone; light green), and the active (dark green) and former (red) floodplain (Globevnik et al. 2020).

2.2. How to claim that (a stretch of) a river is free flowing

The above definitions may appear simple but they will need to be translated into operational tools, adapted to the European context, to set out to achieve the Biodiversity Strategy free-flowing rivers target.

First of all, from the definition of a free-flowing river, proposed in Section 2.1, it may be understood that a river should be totally unhindered by artificial barriers along its entire length, from source to sea. This would be very beneficial for the natural migration of certain species and the natural flow of sediments.

The territory of the European Union, however, is mostly densely populated. The demands on its river network are numerous and serve many purposes, including mobility, farming, inland navigation, electricity production, and agricultural and leisure activities.

As mentioned in Section 1.3.1, the Water Framework Directive recognises and accommodates such needs, while legally requiring to achieve river continuity across the river network by removing or adapting barriers. The free-flowing concept discussed earlier goes further and requires the absence of any artificial barrier. It would be very difficult to eliminate barriers along the whole length of a river and, in many cases, such an ambition would not be compatible with the maintenance of important uses.

The target should therefore be interpreted as aiming to achieve stretches of free-flowing rivers (total absence of artificial obstacles) within a network of fully continuous rivers (WFD – barriers taken down or adapted to allow the achievement of good ecological status).

This concept fits with the idea of embedding river restoration in the overall river basin and nature management: in a continuum going from a highly fragmented river, through varying degrees of continuity, up to full free-flowing status. Restoration could be articulated along varying degrees of action, from the preferred option of avoiding the construction of barriers and thus preventing further fragmentation, through adapting barriers where their removal is not feasible, to the removal of barriers that are obsolete or where removal is indeed a feasible option.

Furthermore, efforts to restore free-flowing status should also be associated with measures to ensure sufficient ecological flow conditions, so as to maximise the benefits to the aquatic ecosystem. Specific guidance on setting and implementing ecological flows in the context of the WFD is provided in CIS Guidance No. 31[22].

Defining criteria and removing barriers

To be able to measure the stretches of free-flowing rivers and thus check progress towards the Biodiversity Strategy targets, it is necessary to establish what would qualify as a free-flowing stretch of river (e.g. possibly minimum length and/or hydromorphological characteristics) and thus count towards the goal. At the moment, there are no commonly agreed methodologies at EU level.

Defining the criteria that a stretch of river needs to fulfil to be considered free-flowing is not a simple exercise. Indeed, if a free-flowing river must support connectivity of water, sediment, nutrients, matter and organisms in all dimensions (longitudinal, lateral, vertical, temporal) to sustain a healthy river ecosystem, such criteria should encompass an evaluation of biotic components together with physico-chemical, hydrological and morphological elements. These are necessary to sustain habitat quality and the supply of nutrients and water. Defining a stretch of free-flowing river would thus depend on the specific characteristics of a water course and should not be independent from an evaluation of river ecological status under the WFD and of habitats conservation status under the Habitats Directive.

Considering the high level of fragmentation of European rivers, the removal of barriers is urgent and an important opportunity to decrease this pressure on rivers and related habitats and species.

Efforts to remove barriers where possible are already underway and should continue to be pursued. This will support improved implementation of the WFD by 2027 and other EU legislation for the protection of nature. Furthermore, the Biodiversity Strategy target calls for action to be taken to remove barriers, and to preserve connectivity or restore it where lost and where possible.

[22] CIS Guidance Document No. 31 “Ecological flows in the implementation of the Water Framework Directive”

Therefore, to combine the need for urgent action towards the 2030 target with a pragmatic and systematic approach that answers the requirements of the Biodiversity Strategy, without hindering in any way actions to achieve the WFD objectives, this document proposes the following actions:

- undertake efforts (or continue) to remove artificial barriers, wherever such opportunities exist, focusing on lateral and longitudinal connectivity, as for these dimensions knowledge and practices are more advanced; and
- develop, in parallel, a set of harmonised criteria, under which river stretches could be defined as free-flowing and thus be counted towards the 2030 goal. This could be the subject of a joint process, involving the Commission and Member States, to achieve a harmonised approach at EU level.

The following sections will elaborate on the proposed approach and offer some indications of existing tools that could be used to facilitate the required actions.

3. Guidance on site selection for barrier removal

3.1. General principles

As illustrated in earlier sections, the Biodiversity Strategy target of at least 25 000 km free-flowing rivers refers directly to the removal of barriers and the restoration of floodplains and wetlands that must be guaranteed to attain the status of free-flowing. It refers therefore to the removal of barriers to both longitudinal and lateral connectivity. Both of these are severely threatened in Europe, with an estimated one transversal barrier every 1.5 km (Belletti *et al*., 2020) and almost 90% of the floodplain area showing severe habitat loss (Globevnik *et al*. 2020).

Work on the restoration of river connectivity is already underway, including in the EU. The following sections will illustrate some of the existing methods to prioritise sites for barrier removal and restoration. Such methods can provide useful guidance in developing a tailored strategy in Member States. However, many of the methods currently in use tend to focus on longitudinal continuity and the removal of transversal obstacles, such as dams. To support the prioritisation for sites to be restored and contribute towards the Biodiversity Strategy goals, including the restoration of floodplains and wetlands through the restoration of lateral connectivity, existing methods should be modified, adapted or completed as necessary to take such requirements into account.

In the prioritisation efforts, the following general principles should be taken into consideration.

Where opportunities exist to remove barriers alongside planned or existing restoration projects, or in connection with protected areas, these should be prioritised. In particular, where actions to restore continuity under the WFD is planned, through the removal of a barrier to longitudinal connectivity, specific priority should also be given to the assessment of barriers to lateral connectivity, so as to restore, in addition, the surrounding floodplain habitats. Synergies should also be sought with other EU legislation or other initiatives. For instance, improving connectivity and river habitats can greatly benefit the European eel, in line with Regulation No 1100/2007. When planning river restoration, it is important to consider possible synergies with the objectives and measures set out in the Eel Management Plans. The same goes for synergies with the objectives and measures of the Pan -European Action Plan for Sturgeons[23]. In general, the migration routes of migratory species need to be taken into account when prioritising barrier removal.

When prioritising barriers for removal, it is also important to consider existing uses in a river basin, including inland navigation, flood defence, energy generation or agriculture. This will help maximise the co-benefits of such operations and avoid significant adverse effects on important uses. The WFD integrates provisions for such uses and sets rules to ensure the integration of different objectives.

Finally, robust prioritisation and planning of action requires robust data. In addition to mapping out the location of barriers to longitudinal and lateral connectivity, it would also be important to identify gaps in knowledge preventing the assessment of connectivity and to put in place processes to fill such gaps. It should be noted that addressing these data gaps could also support the correct implementation of other, related EU legislation.

It is important to note that recent advances in European projects and other initiatives have provided frameworks, tools and methods that can already be used to implement actions to restore river connectivity. For instance, the REFORM project[24] extensively analysed available hydromorphological assessment methods and tools in literature (Belletti *et al*., 2015; Rinaldi *et al*., 2013a). It provided novel frameworks to address hydromorphological characterisation under the WFD and more effectively support the achievement of its goals (Gurnell *et al*., 2016). These frameworks have recently been consolidated in a CEN guidance standard for assessing the hydromorphological features of rivers[25].

3.2. Improving longitudinal and lateral connectivity making use of available knowledge and tools for prioritisation

To claim free-flowing status for a river in the context of the Biodiversity Strategy's target, specific criteria should be met, as described in Section 2.2. This document proposes the theoretical basis and principles for these criteria and key guidelines to support the achievement of the target.

This involves:

- taking actions to improve longitudinal and lateral connectivity, making use of available knowledge and tools for prioritisation;
- monitoring the effectiveness of actions taken; and
- in parallel, gathering data. Fill gaps in longitudinal and lateral connectivity knowledge by mapping barriers in full at the basin scale. Gaps in knowledge for other dimensions of connectivity should be made clear in documentation accompanying data on known aspects of connectivity. Exchanges of best practice can also play an important role.

The following sections propose some guiding principles and a summary of available methods and criteria for prioritising restoration actions for longitudinal and lateral connectivity.

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[23] Pan European Action Plan for Sturgeons - adopted by the Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) in November 2018. It was recommended for implementation under the Habitats Directive in May 2019.

[24] REstoring rivers FOR effective catchment Management - https://www.reformrivers.eu/.

[25] 14614:2020 CEN Standard 'Water quality - Guidance standard for assessing the hydromorphological features of rivers'.

3.2.1. Restoration of longitudinal connectivity

Recommended methods for prioritising barrier removals will vary depending on the spatial scale of planning, the dimension and complexity of project objectives, and the expected uncertainty of a barrier removal project (e.g. unpredictability of economic and socio-political costs of removals, budget availability, and risk of barrier collapse).

As regards the type and size of barriers, large dams, despite their role in providing crucial services such as hydropower electricity, water supply or flood protection, have a significant impact on the quality of a freshwater ecosystem, leading to abrupt disconnection of water, sediment and life (Petts *et al*, 2005; Tickner *et al*, 2020). However, smaller river infrastructures, including some weirs, sluices, fords or culverts, can also have multiple impacts on the flow of river systems. For instance, fish connectivity can be impacted by barriers less than 0.5 m high. In this case, the number and widespread presence along European rivers of such smaller barriers make them a potentially greater threat than large dams. Indeed, the cumulative impact of multiple barriers along a river system is very difficult to assess and might be neglected in assessments.

The first step towards improving longitudinal connectivity focuses on identifying and developing criteria that encompass the multiple factors influencing barrier removal, including available data, objectives, expertise and funding.

Below is a list of criteria that might inform prioritisation scenarios. The source of information can be tailored by catchments and the same criteria can be used at regional, country or the local catchment scale.

The following criteria can be applied to a variety of prioritisation methods (such as those outlined in Table 2, Section 3.2.3):

- Fragmentation:

  On average there are 0.74 barriers to longitudinal continuity for every kilometre of river in Europe, with considerable variations between both countries and rivers within countries (Belletti *et al*. 2020). Three metrics could be used to assess the extent of fragmentation under the tenet that the less fragmented a river is, the easier and more cost-effective it will be to restore continuity. These are:

  - estimated degree of fragmentation (taking into account reporting bias);
  - is fragmentation higher or lower than the regional average; and
  - river continuity conditions (WFD reporting hydromorphological quality element QE2-2) reported as part of River Basin Management Plans.

- Biodiversity and river quality:

  The ecological value of rivers varies enormously across Europe. Fragmentation is one pressure, but not the only one. Restoring connectivity in rivers that are heavily impacted by other stressors only bring the highest benefits for the ecosystems, if other pressures are addressed. This means that, in such situations, actions should be taken in parallel to address other pressures in order to see significant recovery of ecosystems. On the other hand, some catchments represent fluvial hotspots in Europe and restoring connectivity there might generate the greatest benefits. Conversely, the ecological importance of some artificial structures should be recognised: in some cases, structures that are no longer serving their primary purpose have created specific ecological niches. Due consideration should thus be given to the possible presence of native relict species populations that have survived thanks to the isolation. Nevertheless, the restoration of fluvial processes should be considered a priority against the conservation of local habitats formed due to artificial alterations, unless these habitats are crucial for regional conservation purposes. In other cases, barriers might have lost their original function but act as important obstacles to the spread of invasive alien species. Material and information[26] on biodiversity and river quality that are readily available include:

- the chemical and ecological status of the river basin (WFD River Basin Management Plans);
- the status of the biological quality element fish - hydrological stressors tend to affect fish the most out of all biota, both in terms of intensity and sensitivity (WFD River Basin Management Plans); and
- whether the basin is in a protected Natura 2000 site and whether there are protected habitats (including for example habitats of the European Red List of Habitats[27]) or species that would benefit from the restoration.

- Hydromorphological quality:

  Hydromorphological pressures rank amongst the key pressures on surface water bodies in Europe (EEA, 2018) and there is a need to account for hydromorphology in all the steps of river management (Kampa and Bussettini, 2018). Hydromorphology is key for habitat quality and hydromorphological pressures can affect all dimensions of river connectivity and entire ecosystems at river basin scale. Many methods exist to assess river hydromorphological quality under the WFD (Kampa and Bussettini, 2018). Most of these already provide an assessment of river continuity and connectivity. For example, the Morphological Quality Index (Rinaldi *et al.*, 2013b, 2016b) includes indicators for river connectivity processes (longitudinal but also lateral, vertical and temporal) as well as indicators for artificial elements, such as barriers to longitudinal continuity. It was formerly developed for the Italian context, and has been tested and adapted to the European context within the REFORM project (Belletti *et al.*, 2018; Rinaldi *et al.*, 2016b) and is currently applied in various countries.

- Governance and support:

  Support from the local population and stakeholders is a key condition for the success of barrier removal operations. It is an important aspect to be taken into account in barrier removal prioritisation. The benefits of intervention should be evaluated against other possible socio-economic services. In particular, barrier removal may lead to competition between land and river uses and, in some cases, land take may be necessary, which may lead to social concerns. Good communication on the expected benefits of the project and early involvement of the local population and stakeholders, with a view to alleviating concerns and ensuring, where possible, compatibility between different activities, is crucial for a successful project. The value of sites and landscapes and heritage sites adjacent to rivers will also play a role in many cases. For example, the Dam Removal Europe campaign (https://damremoval.eu/) and recent studies of social attitudes to dams in Europe (Rodríguez *et al.*, 2019; Krauze and Vallesi, 2018) indicate that some countries (e.g. France, Spain, Lithuania, Denmark, UK) are much more supportive of dam removal than others (e.g. Germany, Romania). The applicable

[26] Additional data and information on biodiversity and river quality can be gathered from open multitaxa datasets and documents from initiatives such as the European Vegetation Archive (EVA, Chytrý et al. 2020 http://euroveg.org/eva-database), WISER database for species level information (phytoplankton, macrophytes, benthic invertebrates, fish). The EUNIS freshwater classification also provides a common reference for the characterisation of ecosystems (Davies and Moss 1999; Davies et al. 2004; Moss 2008, Rodwell et al. 2018).

[27] Red List of Habitat Types - Nature - Environment - European Commission (europa.eu)

legal set up, governance and institutional support are also very important elements in the analysis.

- Futureproofing:

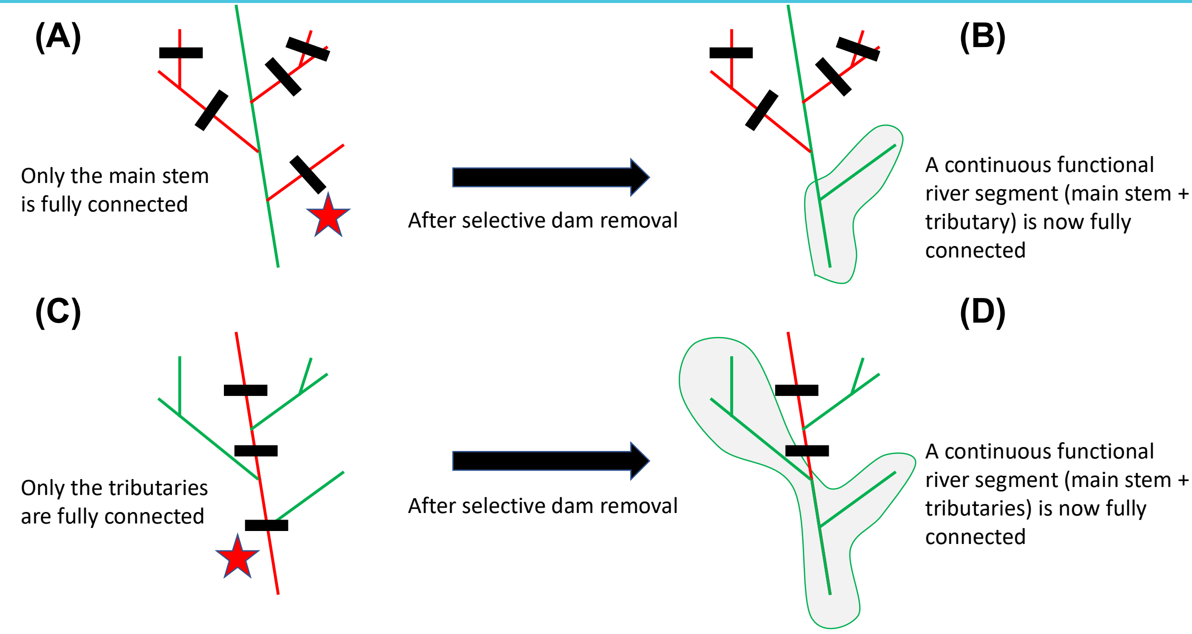
  The impact of barriers often depends on river flow, particularly for low-head barriers. Therefore, it is important to consider predicted changes in river flows to future-proof the benefits of barrier removal. Barrier impacts will increase in places where river flows will decrease, and vice versa. This means that barrier removals could be most beneficial in places where connectivity is most at risk due to droughts and reduced river flows (https://www.eea.europa.eu/data-and-maps/indicators/river-flow-3/assessment). Conversely, it should also be considered whether removing barriers and enhancing the natural water retention of ecosystems could mitigate the impact of floods in areas where more extreme rainfall events might occur as a result of a changing climate.

See Box 2 for an example of a decision tree method for barrier removal based on ecological benefits and costs.

Box 2 - Example: A decision tree for transversal barrier removal, based on ecological benefits and costs

Presented below is an example decision tree and associated scoring criteria that could be developed to choose barriers for removal and use simulations to estimate costs and gains for sites selected (Garcia de Leaniz *et al*. (2021)). Criteria for consideration include:

1. Current impact of a barrier on whole catchment connectivity. Relying on comprehensive evaluation of each aspect of connectivity e.g. ecological, sediment and hydrology.
2. Potential connectivity gain (individually and in combination with other removal sites; see figure below).
3. Current use (in use, abandoned).
4. Age (some barriers have passed their working life).
5. Estimated cost. Broad estimates ($R^2 = 0.3$) can be derived from barrier height for weirs, dams and sluices (Neeson et al., 2015), road crossings, or as a function of length and stream order (Perkin et al., 2020).
6. Public and institutional support. Have barriers been flagged as an issue in biodiversity or hydromorphological studies? Is barrier removal already happening elsewhere?
7. Timeline. For instance, can the project demonstrate progress or completion in time for the European Commission's 2024 progress review of the Biodiversity Strategy?
8. Other constraints (e.g. will barrier removal enable the spread of aquatic invasive species, have toxic sediments accumulated in the upstream impoundment of the barrier?).
9. Level of uncertainty: Of all the criteria developed for informing the prioritisation process, how many of these are unknown?



Example of targeted dam removal (depicted by a star) that seeks to achieve continuous functional river segments (B, D) in cases where the main stem is disconnected from the tributaries due to (A) barriers in tributaries and (C) barriers in main stem (Garcia de Leaniz., C (2020)).

3.2.2. Restoration of lateral connectivity

Many physical restoration measures specified in the national Programmes of Measures under the WFD already aim at improving lateral river connectivity. These include barrier removal (e.g. removal of bed and bank fixation), sediment dynamics improvement (e.g. re-introducing sediment, mobilising sediment flows) and natural flow restoration (e.g. improving variable flow conditions of dam operations). Member States can build on these already existing actions to make progress towards the establishment of free-flowing rivers.

The following are proposed guiding principles for the restoration of lateral connectivity:

- allow for (more natural) movement of water, sediments, nutrients, matter and organisms into and from the active floodplain (through side channels, overbank flows and through the hyporheic zone); and
- remove artificial structures altering the lateral connectivity, aiming at re-activating the former floodplain.

These restoration principles relate to three main aspects of lateral connectivity within the river-floodplain system:

- water and matter exchange (river-floodplain surface water exchange; river-groundwater exchange; sediment transport and bank erosion; river-floodplain organic matter/energy exchange);
- floodplain morphodynamics (natural floodplain habitats; floodplain extent); and
- catchment flow regime (flooding patterns, groundwater flow, upstream sediment loads).

Criteria for prioritising lateral connectivity and floodplain restoration should be similar to those factors considered above for the prioritisation of transversal barrier removal (such as the biodiversity value or potential of a selected site, or governance and support in relation to acquisition and rewetting of land). In particular, lateral barrier removal projects could have direct impacts on land uses developed along the water courses, which may lead to social concerns and hamper the objectives of these projects. Innovative actions to ensure compatibility between different uses and objectives could help, and should be explored, to ensure the success of restoration projects.

Additional criteria include:

- Dimensions

  An extensive area is required to conduct integrated actions, ideally corresponding to the original floodplain area of the river (i.e. returning the floodplain to its natural extent): 10-100 ha and more.

- Space required

  Land acquisition is required in some areas to proceed with the implementation of restoration measures.

- Location

  Restoring the natural water retention capacity in suitable upstream catchments can achieve several policy objectives, including adapting to floods and droughts, improving water quality, storing carbon in soils and creating habitats to benefit biodiversity, and may be replicable in mountain regions across Europe.

- Site and slope stability

  According to Habersack *et al*. (2018), the slope of the river and of the floodplains is one of the most important variables when evaluating the floodplain retention potential: 'Shallow slopes reduce discharge peaks and prolong retention periods, while steeper slopes worsen the effects of retention, especially when the flood wave is totally discharged in the channel.'

- Synergies with other measures

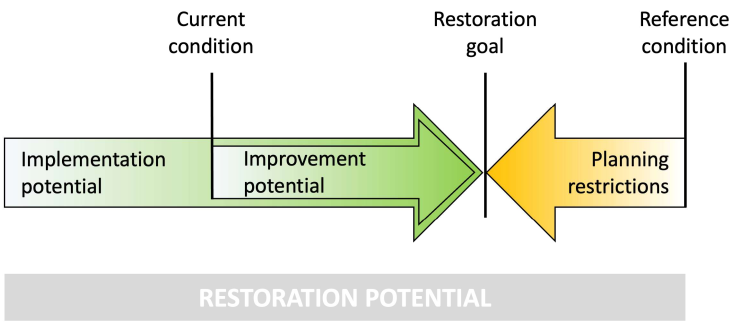
  Opportunities exist to implement other measures such as re-meandering or the creation of wetlands and ponds. In this context, synergies with measures to prevent and reduce flood risk through nature-based solutions should be encouraged. Data on flood prone areas collected through the implementation of the Floods Directive could inform decisions.

It is also recommended to establish concepts and strategies for defining restoration goals and effective measures to ensure sustainable ecological floodplain restoration (an example is provided in Box 3).

Box 3 - Evaluating the potential of floodplain restoration – example of approach

Harms *et al*. (2018) established a basic concept to define the floodplain-specific restoration potential for rivers sections with a minimum of 1000 km^2 catchment area in Germany (Figure below). The reference condition describes the near-natural floodplain condition without human intervention. This condition serves as a guiding image, as planning restrictions are often to be considered (e.g. urban flood protection). The actual restoration goal deviates from the reference condition depending on the floodplain-specific restrictions. The implementation potential of floodplain restoration is related to the restoration goal and decreases with increasing planning restrictions. The improvement potential describes the gap between the current floodplain condition and the restoration goal.

The restoration potential is defined separately for river channel and riparian zone, the active floodplain, and the former floodplain. For river channel and riparian zone, the restoration goal is specified against three planning restrictions - 'impoundment', 'artificial land use in the riparian zone' and 'navigation' - all of which determine a lower restoration goal. For the active floodplain, 'artificial land use in the active floodplain' represents the planning restriction, while the area share of cropland and floodplain forest define the implementation potential. The restoration goal is met by improving the active floodplain to 0% cropland and 30% floodplain forest. For the former floodplain, the evaluation aims at identifying areas that can be reconnected to the active floodplain. Restoration goals are only defined for areas with agricultural or natural land use at a safe distance from infrastructure or residential areas.



Conceptual elements to derive the floodplain restoration potential

3.2.3. Available tools and methods for prioritising barrier removal

Several tools and methods - albeit mostly focused on transversal barriers - have been developed to prioritise barrier removal. These can be used when planning river restoration.

Table 2 below provides a list of selected methods that can be applied at different scales, including an assessment of their complexity, uncertainty and resources required (Mc Kay *et al* 2020).

Table 2 – Recommended methods for prioritizing barrier removals given different spatial scales

The final column indicates resources needed to implement the prioritisation method, defined broadly to include biological data sets, estimates of economic and socio-political costs of removal, and computational/ mathematical modelling expertise (Mc Kay et al 2020).

Spatial scale	Project complexity	Uncertainty	Example	Recommended prioritisation method	Resources required
Small	Low	High	Watershed non-profit with substantial field expertise and goal of increasing access to upstream habitat	Multi-stakeholder priority setting by discussion/committee	Low

			for a single species, where individual owner attitudes are difficult to predict		
Small	Low	Low	Local transportation authority with good asset database and jurisdiction over all barriers	Optimisation within jurisdictional constraints	Medium
Large	Low	High	Regional prioritisation of dams to maximize total accessible river miles, where socio-political costs depend on individual owner attitudes and are difficult to predict	Combination of mathematical optimisation and/or multi-stakeholder priority setting	Medium
Large	High	High	Regional prioritisation of dams to benefit a suite of migratory fish and non-fishery objectives	Standing priorities addressing a suite of ecological metrics	High

3.2.4. Monitoring the effectiveness of actions taken

For the 25,000km free-flowing river target to be effective in terms of river restoration, it should be determined how connectivity improvements will be monitored. To monitor gains in connectivity, several complementary indicators, including biotic and hydromorphological ones, should be used, bearing in mind that benefits will in several cases not be immediate. Indeed, in some cases, it may take many years before a positive effect is detected against the natural background noise. Although widespread monitoring might not be possible, it is suggested that a number of key sites be carefully monitored with a before-after-control-impact (BACI) design to enable evaluation of the improved connectivity.

3.2.5. Gathering data and mapping

To support the strategic development of barrier removal efforts, data should be gathered in parallel to fill gaps in knowledge and improve planning. The data needed include: barrier location, including information on barrier type, height, operation (hydropower, irrigation, drinking water supply, flood protection, sediment management etc.), in-use status (serves a purpose or abandoned), and whether mitigation measures are in place and functional (e.g. fish passes).

In an ideal scenario, all barriers in a basin or country would be mapped with information on location, type, height, operation and status (in use or obsolete). The data gathering exercise would contribute to achieving such a scenario. However, barrier removal efforts will more likely be based on data in known existing datasets on barriers, with varying information completeness.

A suite of tools and methods is available with which to fill gaps in barrier inventories (Table 3). This enables on the one hand the prioritisation exercise, and on the other a contribution to fill data gaps in the longer term. These range from surveying an entire basin or sub-basin to generating a correction factor for existing estimates of barrier numbers based on sample reaches/stretches/sections. Availability of data and tools is greater for longitudinal barriers than lateral barriers, and methods for mapping such structures should be further developed.

Table 3 – Existing sources of longitudinal and lateral barrier locations and tools for collating and generating new databases

Database or tool	Method	Barrier type	Parameters	Longitudinal or lateral	Spatial scale	Link
Existing database	Collating data from multiple sources	All	Location, height and type	Longitudinal	Europe	https://amber.international/european-barrier-atlas/
Existing database	Collating data from multiple sources and satellite imagery	Dams	Location, height and type	Longitudinal	Global	http://globaldamwatch.org/data/ https://globalhydrologylab.github.io/GROD/validation#multi-channel-rivers
Assessing existing databases	Using walkover surveys to validate and correct existing estimates of barrier distribution	All	Barrier location	Longitudinal	Basin	Quantifying river fragmentation from local to continental scales: data management and modelling toolbox (Jones et al. 2020) Jones_etal_barrier_methods_authorea.pdf
Collecting new data on longitudinal barriers	Standardised barrier data collection tool	All	Barrier location, height and type	Longitudinal	Reach	https://portal.amber.international/

						https://www.river-obstacles.org.uk/
Barrier classification key	Harmonising existing records of barrier types	All	Barrier features and function	Longitudinal	Any	https://www.authorea.com/users/338059/articles/473218-quantifying-river-fragmentation-from-local-to-continental-scales-data-management-and-modelling-toolbox https://globalhydrologylab.github.io/GROD/validation#multi-channel-rivers
Duplicate exclusion	Combining existing records from overlapping databases	All	Barrier location, height and type	Longitudinal	Any	https://www.authorea.com/users/338059/articles/473218-quantifying-river-fragmentation-from-local-to-continental-scales-data-management-and-modelling-toolbox
Existing Database	Collating data from multiple sources	All	Location, height and type; in use or not	Longitudinal and lateral	France	http://carmen.carmencarto.fr/66/ka_roe_current_metropole.map
Artificial elements (Indicators of artificiality)	Data can be obtained from multiple sources	All (artificial elements)	Main types of artificial elements that disrupt river hydromorphology		Europe	https://www.reformrivers.eu/methods-models-tools-assess-hydromorphology-rivers-part-2-thematic-annexes

In addition, methods should be refined and developed to improve the assessment of lateral connectivity for floodplains and wetlands. In some Member States, floodplain assessment methods already exist such as the German floodplain condition assessment illustrated in Box 4 below.

Box 4 - Practice example: The German floodplain assessment

The German floodplain condition assessment is not based on a specific programme for floodplain monitoring, but operates with different data sources being combined in the assessment. These are a digital elevation model, land cover/land use satellite data, aerial orthophotography, flood risk maps (Floods Directive), monitoring data of relevant national and European habitat types (Habitats Directive) and river hydromorphological data (Water Framework Directive) (Koenzen *et al*. 2021). The assessment method distinguishes active and former floodplain based on a national inventory of flood protection structures. The condition assessment covers all German rivers with a minimum catchment size of 1000 km2 and is done for 1km-floodplain-segments of the active floodplain. It evaluates the degree of alteration from a near-natural reference condition. The assessment is divided into three modules: floodplain morphology; floodplain hydrology; and vegetation and land use. An assessment module for the biological condition is under development (Januschke *et al*. 2018).

3.2.6. Longer-term perspective for managing river fragmentation

The previous sections offered some guiding principles and a summary of available methods and criteria for prioritising restoration actions for longitudinal and lateral connectivity, and thus facilitate the planning of restoration activities with the available data. However, in a longer term perspective, the approach to addressing Europe's heavy river fragmentation could be refined, in light of new data gradually being collected and the experience gathered in removing artificial barriers. This exercise would aim to better manage the connectivity of the river system at the catchment scale and address the needs of the surrounding environment in a more integrated fashion.

A useful concept in this context could be that of the functional river unit, which would help define the minimum river-length that should be considered for a stretch to qualify as free-flowing. Defining a functional river unit should include an evaluation of biotic components as well as physico-chemical, hydrological and morphological elements, necessary to sustain a healthy ecosystem. Such an evaluation should not be independent from an evaluation of river ecological status under the WFD and of habitats conservation status under the Habitats Directive.

In general, the following could be useful in refining the approach to address river fragmentation.

1. **Develop a definition for functional river units** for different stream types and basins present under the management of each Member State. For example, alpine rivers have a high degree of natural fragmentation, so functional river units might only be comprised of a few headwater reaches whilst lowland rivers may be dependent on connectivity between many stream orders and the floodplain of the main stem. This would allow the identification of river functional units within different basins and the pressures preventing them from attaining free-flowing status. The definition of river functional units can support an integrated concept for managing connectivity in all dimensions.
2. **Define or adapt methods and strategies for assessing free-flowing river status** which, based on the functional river units previously defined, can evaluate quality of river forms and processes observed. This could be done by adopting already existing criteria such as those derivable from the ecological status of the WFD (e.g. Morphological Quality Index and Multi-scale Hierarchical Framework) (Gurnell *et al*., 2016), or other existing methods for river characterisation (Brierley and Fryirs, 2005; Opperman *et al*., 2010).
3. **The assessment of free-flowing river status could be supported by an improved river monitoring framework** designed for the assessment of connectivity in the context of EU policy.

4. **Further refine prioritisation of restoration actions**. Prioritise functional river units (previously defined) for restoration using criteria proposed for the evaluation of free-flowing river status, such as ecological status, estimated levels of fragmentation and socio-economic benefits and possible impacts, and propose restoration projects setting specific targets and monitoring plans to assess their achievement.

Specific initiatives and projects on a large scale would help create a pro-active network of experts, researchers and stakeholders. Such initiatives would include, in particular, mapping the current state of rivers and, on this basis, proposing and prioritising restoration projects. These restoration projects could provide the context for defining functional river units in different geographical contexts and of showing the benefits of large-scale initiatives. Previous research carried out in Europe can also support the building of a more comprehensive body of knowledge and support the evolution of an integrated approach to river restoration at the appropriate scale. For instance, the previously mentioned REFORM project, under the Seventh Framework Programme for research and technological development, proposed a multi-scale hierarchical framework for developing an understanding of river hydromorphological behaviour to support river management in the context of the WFD. Furthermore, metrics on connectivity exist in literature related to the different river components (e.g. sediment, fish, network), or to the different connectivity dimensions (longitudinal, lateral, vertical). These could contribute to refining the approach to addressing river fragmentation. Box 5 below lists a selection of common metrics that could be used within the scope of this document.

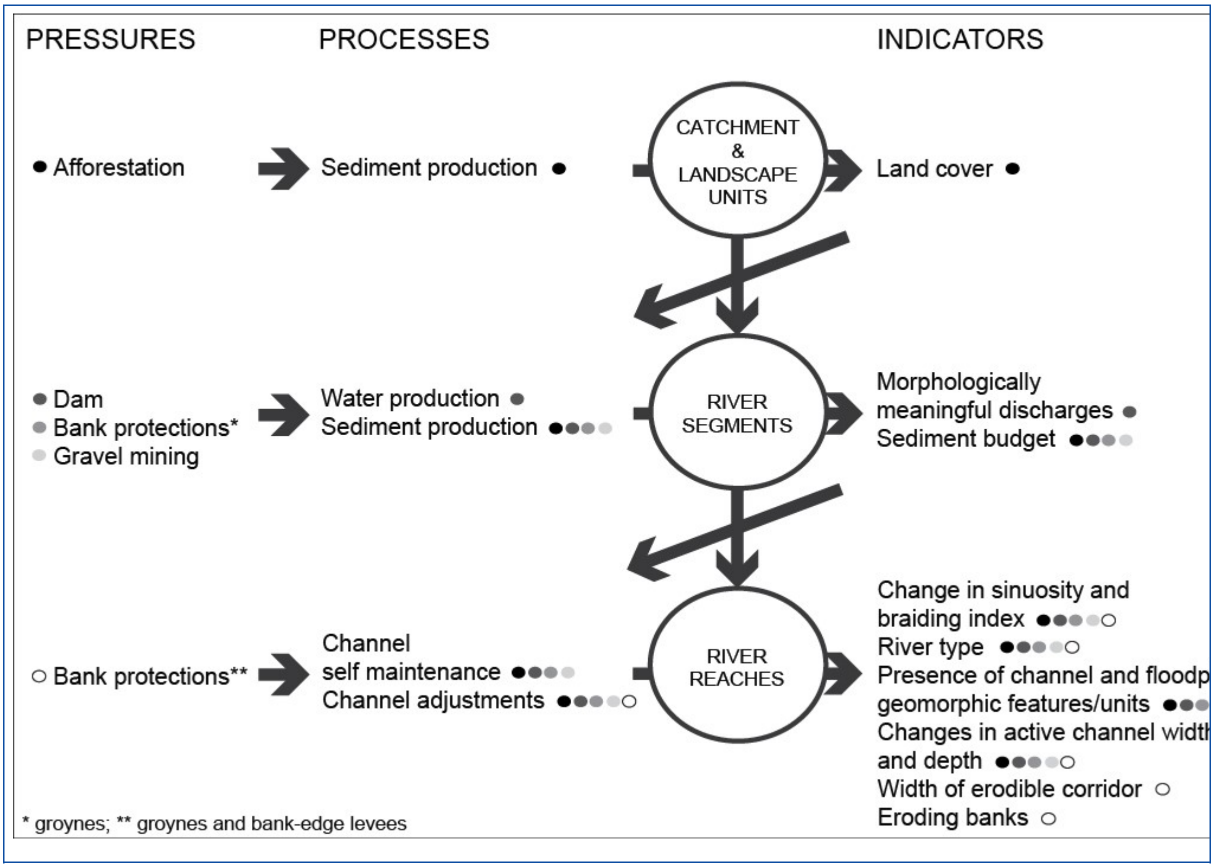
Box 5 Example: Defining a functional river unit using hydromorphology

River management and restoration actions often focus on individual reaches or stretches. If properly identified, i.e. according to a hierarchical organisation of river systems, reaches can integrate both local scale, upstream processes and human pressures. According to the hierarchical organisation of river systems, a reach is defined as a ‘section of river along which boundary conditions are sufficiently uniform that the river maintains a near consistent internal set of process-form interactions’ (Gurnell *et al*., 2016). The delineation of a functional river unit for biota (e.g. functional process zone) should start with a delineation and characterisation of hydromorphological properties.

Within this context, a functional river unit might be identified according to the same criteria that are used to delineate hydromorphological reaches, i.e. provided that this is identified considering both local and upstream processes, using the following indicators (see also Gurnell *et al*., 2016; Gonzalez del Tanago *et al*., 2016):

- local scale indicators: channel and floodplain morphology (see Rinaldi *et al*., 2016a), absence or negligible presence of artificial discontinuities/barriers (i.e. that impede the flux of water, sediment, wood and other materials along the reach and the river-floodplain connectivity), valley gradient, confinement and natural discontinuities (i.e. that can determine the limit of another functional river unit);
- upstream indicators: absence of significant artificial discontinuities/elements (i.e. that impede the flux of water, sediment, wood and other materials towards the reach), consistent topography / land use assemblage (i.e. that originate comparable fluxes/delivery conditions of water, sediment, wood and other materials towards the reach).

The figure below shows an example of assessment of hydromorphological processes and indicators affected by human pressures along the Magra river (Italy) from catchment to reach scale. Once the relevant spatial scale units are delineated (i.e. functional river unit or in that case river reaches and segments), the effect of human pressures over spatial scales can be identified, for both processes and indicators. These are summarised by different grey-scale dots, where each grey dot corresponds to a single pressure. Each grey dot shows the effect of one pressure on processes and indicators at one scale and its influence on processes and related indicators at smaller spatial scales (from Belletti *et al*., 2016).



4. EU financing instruments – An overview

Depending on the scale, location and type of measures taken, river restoration entails costs. Securing sufficient funding is therefore a necessary step when planning river restoration operations. EU funding instruments, either direct funds or shared management funds, can contribute with resources to river restoration efforts, including in combination with other EU, national or local funds. Synergies and complementarities between funds should be explored to ensure successful implementation of projects beyond the restoration measures alone, including other aspects such as awareness raising, stakeholders' involvement and communication activities.

This chapter explores some of the EU funding mechanisms available that could be used to finance or co-finance such restoration efforts. The list provides an overview of the EU funding programmes that could be used, but the list is not meant to be exhaustive.

European Funding Programmes	Cohesion Policy Funds	Agriculture and Maritime Policy	Financial Institution Instruments and technical support

LIFE Horizon Europe	ERDF Cohesion Fund	EAFRD EMFAF	InvestEU

4.1. European Funding Programmes

A number of direct funding grants from the European Commission or its executive agencies exist for projects with specific objectives for river restoration.

4.1.1. LIFE programme (LIFE)

About: The LIFE programme is the EU's funding instrument for the environment and climate action. Its general objective is to help develop, implement and enforce EU environmental and climate policy and legislation by co-financing projects with European added value.

The LIFE programme is divided into two fields, one for environment (representing 64% of the overall financial envelope and including two sub-programmes for 'Nature and Biodiversity' and 'Circular Economy and Quality of Life') and one for climate action (representing 36% of the envelope and including two sub-programmes for 'Climate Change Adaptation and Mitigation' and 'Clean Energy Transition').

Any public or private organisation registered in the EU can apply for funding. The funding can cover standard, strategic or technical assistance projects[28], with projects lasting on average 3-5 years. The project budget depends on the project type but both fields co-finance standard LIFE projects with up to 60% of the total eligible project costs. For nature and biodiversity standard projects in the Environment field, co-financing can reach up to 75% in specific cases. The project leader and each of the project partners have to contribute financially to the project. Project proposals that show synergies with EU policies different from those covered by the LIFE programme and with other EU funding mechanisms will receive bonus points in the evaluation. However, LIFE programme funding must not overlap with funding from other EU programmes.

The strategic projects, mentioned above, act as a LIFE catalyst for mainstreaming efforts and ensure the presence of environmental safeguards in activities under other EU funding programmes and instruments. These LIFE projects help Member States achieve full implementation of strategies or action plans required by the EU environmental and climate legislation and are implemented at national or regional scales, with massive potential impacts. To do this, strategic projects use financing opportunities under other funding programmes/sources, such as national funds, and create synergies with them. In fact their success depends on close cooperation between national, regional and local authorities and the non-state actors affected by the objectives of the LIFE programme.

River restoration, with its role in supporting biodiversity and habitats protected by the Habitats Directive, and its potential synergies with climate adaptation policies and the use of nature-based solutions, e.g. water retention measures, could fit under both fields of the LIFE programme. In fact, the LIFE programme is already funding a significant number of river connectivity measures both under traditional/standard and strategic projects.

[28] Standard projects pursue the specific environmental objectives of the LIFE programme; strategic projects help Member States achieve full implementation of strategies or action plans required by the EU environmental and climate legislation and are implemented at national or regional scales; technical assistance projects help develop capacity to participate in the LIFE programme and other EU financial instruments, to pursue LIFE objectives.

Budget 2021 – 2027: EUR 5.432 billion

How to access funding: Calls for proposals are published online once a year[29]

More information: https://cinea.ec.europa.eu/life_en

Example (traditional/standard project): **LIFE CONNECTS - River connectivity, habitats and water quality towards restored ecosystem services (LIFE18 NAT/SE/000742)**

The overall objective of the LIFE CONNECTS projects is to improve the conservation status of the target species and the ecological status along around 150km of seven target rivers.

In under six years the project, coordinated by the County Administrative Board of Skåne in collaboration with a variety of stakeholders, will work on a variety of solutions. These include removing hydropower plants and dams, creating fauna passages and improve migration paths at barriers, innovative passage solutions that enable both hydropower production and fish migration as well as riverbed restorations to gain more natural habitats and improved water quality.

The goal is to improve the survival and reproduction of endangered fish species such as Atlantic salmon and European eel, as well as the endangered species of freshwater pearl mussel and thick-shelled river mussel.

Research and information efforts linked to river restorations within the project will constitute an important part of the project to link river restoration and sustainable water management.

Total budget / EU contribution (2019 – 2025): EUR 9 771 435 / EUR 5 255 079

More information on the project: https://lifeconnects.se/?lang=en

Example: **Living River Lahn - one river, many interests** (LIFE14 IPE/DE/000022)

The project, led by the Hessian Ministry of the Environment, Climate Protection, Agriculture and Consumer Protection, aims to help implement the Water Framework Directive, to achieve 'good ecological status' for surface waters in the catchment area of the Lahn River (DE), an eastern tributary of the Rhine.

Living River Lahn will pilot the alternative uses of inland waterways that previously gave priority to waterborne transport. It will demonstrate an integrated multi-stakeholder approach to managing the Lahn catchment, which crosses several administrative boundaries, improving the ecosystem services it provides.

Restoration of near-natural conditions will improve the Lahn's ecological status and biodiversity and create opportunities for sustainable tourism. The project will also create water retention areas and identify pollution sources to improve water quality. Lessons from and concepts developed by the project will be applicable to other regions and catchment areas in Europe.

In addition to the LIFE budget itself, the project will facilitate the coordinated use of around EUR 28 million in complementary funding from the European Agricultural Fund for Rural Development (EAFRD) and national funds.

River restoration total budget/ LIFE contribution (2015 – 2025): EUR 15 709 406 / EUR 8 496 390

More information on the project: https://www.lila-livinglahn.de/en/start

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[29] LIFE calls for proposals: https://ec.europa.eu/easme/en/section/life/calls-proposals

4.1.2. EU framework programme for research and innovation (Horizon Europe)

About: Horizon Europe is the EU's flagship research and innovation programme. It can support research activities underpinning the deployment of EU-level projects (such as e.g. scientific research on ecological processes, development of tools for mapping and assessment) and innovation actions.

The transnational character of Horizon projects makes the fund particularly interesting. Freshwater is not a mission per se but features under different headings, including the Healthy oceans, seas, coastal and inland water mission[30] and the European Partnerships[31], e.g. European Partnership on water security for the planet (Water4All) or European Partnership for rescuing biodiversity to safeguard life on Earth.

The Commission recently adopted Horizon Europe's first strategic plan 2021 – 2024 with one of the four strategic orientations dedicated to "Restoring Europe's ecosystems and biodiversity, and managing sustainably natural resources": under this heading, river restoration projects could find their place.

Budget 2021 – 2027: EUR 95.5 billion

How to access funding: Two-year work programmes announce the specific areas that will be funded by Horizon. The work programmes will match the strategic guidelines in order to directly contribute to EU priorities. Funding and tender opportunities are published during the year[32]. Each call gives more precise information on the questions the Commission would like to address.

More information: https://ec.europa.eu/info/horizon-europe_en

Horizon Results Platform: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-results-platform

Example: **Adaptive Management of Barriers in European Rivers** (AMBER)

The AMBER project, coordinated by the University of Swansea, studied adaptive management for the operation of barriers in European rivers, to achieve a more effective and efficient restoration of stream connectivity. To do this, the project team developed tools, models, and toolkits that will allow hydropower companies and river managers to maximise benefits and minimise ecological impacts. Such management would improve energy security, help protect jobs, and boost European competitiveness, particularly in rural economies.

Total budget / EU contribution (2016 – 2020): EUR 6.23 million / EUR 6. 02 million

More information on the project: https://amber.international

[30] https://ec.europa.eu/info/horizon-europe/missions-horizon-europe/healthy-oceans-seas-coastal-and-inland-waters_en

[31] https://ec.europa.eu/info/horizon-europe/european-partnerships-horizon-europe/candidates-food-security_en

[32] Funding and tender opportunities currently still under Horizon 2020: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/h2020

4.2. Cohesion policy funds

About: Cohesion policy targets all regions in the EU to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life.

To reach these goals and address the diverse development needs in all EU regions, EUR 330.2 billion (2018 prices) – almost a third of the total EU budget – has been set aside for cohesion policy for 2021-2027. Most of this is concentrated in less developed European countries and regions, to help them catch up and reduce the economic, social and territorial disparities that still exist in the EU.

The European Rural Development Fund (ERDF), the European Social Fund Plus (ESF+) and the Cohesion Fund will support five policy objectives in the 2021-2027 programming period. Those will focus on more competitive and smarter, greener, more connected, more social and inclusive Europe, and a Europe that is closer to its citizens. The ERDF and the Cohesion Fund could also provide support for river restoration and more in general for water-related projects.

Management of these funds is shared between the Commission and the Member States. Each Member State prepares a partnership agreement, which is then implemented through programmes at national or regional level, including sub-regional territories such as cities, as well as programmes for cross-border, transnational and interregional cooperation. These programmes determine the strategy and investment priorities to be supported by each fund to address the specific development needs and challenges of the territory covered, as well as how they complement other EU instruments, and avoid overlaps with them.

4.2.1. European Regional Development Fund (ERDF)

About: The ERDF focuses its investments on several key priority themes under the "thematic concentration" requirement: innovation and research, the digital agenda, support for small and medium-sized enterprises (SMEs), environment and the net-zero-carbon economy.

At least 30% of Member States ERDF resources will be allocated to green investments, covering energy, climate change and risk prevention investments, as well as promoting sustainable water management, the transition to a circular economy and the improvement of biodiversity, green infrastructure, pollution reduction, and sustainable multimodal urban transport.

Beneficiaries who can receive support from the ERDF include public bodies, private sector organisations (especially SMEs), universities, associations, NGOs and civil organisations, depending on the priorities identified in the programmes.

Among the investment areas, river restoration can be supported under the specific objective of ERDF dedicated to protect and preserve nature, biodiversity and green infrastructure, and reduce all forms of pollution.

Measures may include: protection and management of river basins, water services and wetlands; drought and flood prevention; as well as protection and improvement of natural heritage, in support of socio-economic development and sustainable tourism.

Budget 2021 – 2027: EUR 192 billion (2018 prices)

How to access funding: Contact the relevant managing authority for the programme in your region. This body is responsible for implementing the programme by setting out the selection criteria and application procedures for projects.

More information: https://ec.europa.eu/regional_policy/en/funding/erdf/

Example: ERFD **SUNRISE** (Stoke and Urban Newcastle Rediscovering Its Secret Environment)

The SUNRISE project worked in 16 urban sites in North Staffordshire (UK) to create new wildlife habitats, improve water quality and reduce flooding. The project is led by the Stoke-on-Trent City Council and the Staffordshire Wildlife Trust and covers five key themes: watercourse restoration and improvement, wetland habitat creation and / or improvement, woodland management, grassland habitat creation and / or improvement and invasive species control.

Each of the project sites has been selected as an area where these tasks can improve the existing habitat for wildlife and where communities can access and enjoy those improvements, but also to improve / create a network of inter-connected and improved habitats for the species which use them.

Total budget / EU contribution (2019-2020): ~ EUR 4.1 million / ~ EUR 2.4 million

More information on the project: http://www.erdf-sunrise.co.uk

Interreg

About: Interregional cooperation (mostly Interreg programmes) is one of the two goals of cohesion policy, funded through the ERDF, supporting cooperation across borders through project funding.

Its aim is to jointly tackle common challenges and find shared solutions in fields such as health, environment, research, education, transport, sustainable energy and more.

Interreg covers four types of cooperation: cross border, transnational, interregional and cooperation between outermost regions[33] and their neighbouring environment. 60% of the resources must be allocated to three of the five policy objectives, and supporting the policy objective 'A greener Europe' is compulsory for each programme. The maximum EU co-financing rate is of 80% (up to 85% for outermost regions).

Budget 2021 – 2027: ERDF EUR 8.4 billion (2018 prices) (EUR 5.81 billion for cross-border cooperation, EUR 1.47 billion for transnational cooperation, EUR 0.49 billion for interregional cooperation and EUR 0.28 for outermost regions).

How to access funding: Calls for projects are published online[34].

More information: https://interreg.eu/about-interreg/

Example: **MEASURES (M**anaging and restoring aquatic**E**cologic**A**l corridors for migratory fi**S**h species in the Dan**U**be **R**iv**Er** ba**S**in**)**

MEASURES is a 3-year Interreg project within the Danube Transnational Programme and co-funded by the EU with 12 partner institutions from 8 countries within the Danube River Basin.

It aims to pave the way for the establishment of ecological corridors through identifying key habitats and initiating protective measures along the Danube and its main tributaries.

A methodology for migratory fish habitat mapping will be developed and tested as well as a standardised strategy (including prioritisation) for restoring ecological corridors, that will support implementation in future management plans.

Total budget / EU contribution (2016 – 2020): EUR 2.51 million / EUR 2.04 million

[33] See EU & outermost regions - Regional Policy - European Commission (europa.eu)

[34] Interreg calls for projects: https://interreg.eu/call-for-project/

More information on the project: http://www.interreg-danube.eu/approved-projects/measures

4.2.2. Cohesion Fund (CF)

About: The Cohesion Fund is aimed at Member States whose Gross National Income (GNI) per inhabitant is less than 90 % of the EU average[35]. It aims to reduce economic and social disparities and to promote sustainable development.

The Cohesion Fund will support environmental infrastructure and priority EU projects in Trans-European Transport Networks. It will cover projects for energy efficiency, use of renewable energy, sustainable urban transport that present clear environmental benefits, and investments promoting the circular economy, climate change adaptation and mitigation, risk prevention and management, including ecosystem-based approaches and preserving and protecting the environment through investment, also in the water sector.

Budget 202-2027: EUR 42.6 billion, of which EUR 10 billion contribute to the Connecting Europe Facility – Transport (2018 prices)

How to access funding: Contact the relevant managing authority for the programme in your region. This body is responsible for implementing the programme by setting out the selection criteria and application procedures for projects.

More information: https://ec.europa.eu/regional_policy/en/funding/cohesion-fund/

Example: **WISŁOKA WITHOUT BARRIERS - Removal of barriers to migration of aquatic organisms on the Wisłoka River and its tributaries, the Ropa and the Jasiołka**

This project, led by the state water holding Polish Waters Regional Water Management Board Krakow, aims to restore the ability of fish and other aquatic organisms to freely migrate up and down the river Wisłoka and its tributaries, while simultaneously maintaining a stable water intake and other elements of the infrastructure.

This should improve the ecological state of the water of the Wisłoka and its tributaries, which is an important migratory passage in this part of Europe. The basic mission of the project is to construct new fish passes or modernise existing ones at seven weirs which currently represent migratory barriers to fish. This is to be complemented by monitoring the effectiveness of the projects.

Total budget / EU contribution (2018 – 2021): ~ EUR 6.4 million / ~ EUR 5.5 million

More information on the project:
https://wislokabezbarierhome.files.wordpress.com/2020/10/2020-10-19-wisloka-en-spread.pdf

4.3. Funds under agriculture and maritime policy

4.3.1. European Agricultural Fund for Rural Development (EAFRD)

About: For the new common agricultural policy (CAP), which is due to enter into force in 2023, each Member State will design a national CAP strategic plan covering both the first and second pillar of the CAP. Thus these plans will for the first time combine funding for both income

[35] List of Member States eligible for the CF (2021 – 2027): Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.

support and market measures (covered by the European Agricultural Guarantee Fund (EAGF)) and rural development (supported by the European Agricultural Fund for Rural Development (EAFRD)).

The strategic plans, where Member States set out how they intend to plan CAP funding, are approved by the Commission. When designing their strategic plans, EU countries will contribute to the nine specific objectives of the new CAP through a toolbox of different instruments and interventions, which can be shaped around their specific needs.

Among these nine specific objectives (SOs) there is one related to climate change mitigation and adaptation (SO4), one related to the sustainable management of natural resources (SO5) and one related to nature and biodiversity (SO6).

Member States have considerable flexibility in what interventions they choose in their CAP plans and how they design them to respond to their needs. Compared to the 2014-2020 funding period there is an increased focus on performance and results, and Member States will need to increase the overall environmental and climate ambition.

All the measures that were available in the rural development programmes largely remain available as interventions for the Member States to select.

The most relevant interventions with regard to removing barriers and restoring hydromorphological conditions consistent with good status under the Water Framework Directive (WFD) and favourable conservation status for habitats and species include:

- Investments (article 73):
    - of which non-productive investments would be the most relevant for barrier removal/hydromorphological restoration;
    - other options include natural retention measure investments where these are chosen as part of preventive measures against natural disasters, adverse climatic events or catastrophic events in agricultural and forest land.
- Environment, climate and other management commitments (art. 70) - covering the management of the restored areas, or supporting the conversion of e.g. arable land into grassland or floodplains.
- Area-specific disadvantages resulting from certain mandatory requirements (Natura and WFD compensation payments – article 72) where mandatory measures are adopted by the Member States in the relevant plans – River Basin Management Plans, Natura 2000 – these can be compensated for through the CAP plans.

CAP interventions are unlikely to support a river restoration project entirely; however, they could finance certain activities under a project. At least 35% of the EAFRD budget of each CAP plan must be dedicated to measures addressing environment and climate (as well as animal welfare) objectives. The above-mentioned interventions would count towards this ring-fencing.

Budget 2021 – 2027: EUR 387 billion (for both EAGF and EAFRD)

How to access funding: The CAP strategic plans have to be prepared at national or regional level and will start in 2023. Countries have to carry out a SWOT analysis and set out their needs with respect to nine specific objectives of the new CAP.

For three of the specific objectives (SO 4, 5, and 6 – which relate to climate change, natural resources and biodiversity) this would require that the objectives of the WFD and the RBMPs and the needs for biodiversity and Nature legislation are identified and addressed where relevant within the interventions of the CAP strategic plan.

On the basis of this assessment, Member States will describe in their CAP plans how they intend to address the needs identified through different interventions, an adequate budget allocated to these interventions, and set targets for result indicators.

More information: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en;

https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-strategic-plans_en

https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/rural-development_en

Examples: (from the 2014-2021 RDPs)

Under the 'non-productive investments' measure, funds have been allocated to remove redundant in-river/bank side structures necessary to help achieve water and biodiversity objectives (often when accompanying an agri-environment scheme). These include investments in wetlands and floodplain restoration, and measures to restore the natural hydromorphology and improve water quality and quantity (stream restoration, restoration of meanders, implementation of riparian buffer zones, and implementation of wetlands for natural water purification).

Under the 'restoring agricultural potential after natural disasters and prevention' measure, funds have been allocated to restore flood defence systems, including natural retention measures, such as renaturing river stretches.

Under the 'village renewal and basic services' measure, funds have been allocated to projects aiming to re-establish river continuity, improve the water structure and create habitats, and improve the ecological status of water bodies, while at the same time taking advantages of synergies with flood protection; projects aiming to recreate wetlands, ponds and ditches to improve nutrient retention and water quality.

4.3.2. European Maritime, Fisheries and Aquaculture Fund (EMFAF)

About: The EMFAF targets funding from the EU budget to support low-impact fishing and aquaculture and focuses on the enabling conditions for developing a sustainable economy in coastal, island and inland areas, through the economic diversification of local communities.

It also includes projects that contribute to good marine environmental status, protect and restore marine biodiversity and ecosystems, effectively manage, restore and monitor Natura 2000 sites, and rehabilitate inland waters in accordance with the Water Framework Directive.

The EMFAF is implemented through national programmes prepared by Member States and approved by the Commission ('shared management'). Each Member State is allocated a share of the total fund budget, which is used to co-finance projects, along with national funding.

In this framework, Member States select the eligible projects in accordance with their own criteria. Under the EMFAF, there are broad "specific objectives" describing the thematic areas of support under the Fund, which are organised along four priorities[36]. Member States indicate

[36] (1) Fostering sustainable fisheries and the restoration and conservation of aquatic biological resources; (2) Fostering sustainable aquaculture activities, and processing and marketing of fisheries and aquaculture products, thus contributing to food security in the EU; (3) Enabling a sustainable blue economy in coastal, island and inland areas, and fostering the development of fishing and aquaculture communities; (4) Strengthening international ocean governance and enabling seas and oceans to be safe, secure, clean and sustainably managed.

in their programme the most appropriate means for achieving these specific objectives and identify a variety of projects framed with their own national eligibility rules. The national authorities and the Commission are jointly responsible for implementing the programme.

Among the investment areas, concrete projects for river restoration can be supported under the specific objective of the EMFAF dedicated to protecting and restoring aquatic biodiversity and ecosystems, including in rivers.

Budget 2021 – 2027 (as part of the overall agreement on the Multiannual Financial Framework (MFF) 2021-2027): EUR 6.108 billion in total. Of which EUR 5.311 billion is implemented through national programmes jointly financed by the EU and Member States ('shared management') and EUR 797 million directly by the Commission ('direct management').

How to access funding:

Under shared management - first check with the national authority[37] managing the programme in your country. Then follow the relevant application procedures so it can check the eligibility of your project and whether it meets the relevant selection criteria and investment priorities set at EU and national level.

Under direct management - check the calls for proposals[38] published by the European Climate, Infrastructure and Environment Executive Agency (CINEA) to which the Commission has delegated the implementation of part of EMFAF under direct management.

More information:

For EMFF 2014-2020 - https://ec.europa.eu/fisheries/cfp/emff_en

For EMFAF 2021-2027 - https://ec.europa.eu/oceans-and-fisheries/funding/emfaf_en

For Commission paper on sea basin analyses - https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2020)206&lang=en

Examples of projects financed under the European Maritime and Fisheries Fund (EMFF) 2014-2020 (under 'shared management'): As of the end of 2020[39], 847 operations in total (with EUR 19.6 million of EMFF committed and EUR 5.7 million of EMFF spent) are reported to be related to the restoration of inland water ecosystems and/or species[40]).

Example: **Prioritised Salmon Habitat Restoration in the Galloway River Catchments**

Water quality and habitats in Galloway river catchments utilised by salmon have been degraded by human activities and need to be restored, for salmon to survive long term. This project aims to develop a robust method to prioritise areas for habitat restoration, delivering maximum benefits for salmon populations at catchment scale.

It focuses specifically on implementing a programme in cooperation with key local stakeholders and exploring new opportunities to undertake habitat improvement works, to help address future problems associated with climate change. The main focus of the project is to harness

[37] National authorities managing the EMFF/EMFAF: https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/national_authorities.pdf

[38] https://cinea.ec.europa.eu/european-maritime-fisheries-and-aquaculture-fund/emfaf-calls-tenders_en

[39] Infosys data are available only up to 31.12.2020 and are developed by the Commission's Fisheries and Aquaculture Monitoring and Evaluation (FAME) Support Unit.

[40] Note that the inland water restoration projects supported by the EMFF were screened on the basis of their description. This approach has some limitations because it is up to the national authorities to decide the level of detail they enter for the description in the reporting tool Infosys. According to the data provided in this way, the most common descriptions of operations supported in this area are: i) operations supporting investments to create fish passages and similar operations related to watercourse restoration; ii) studies related to restoration (e.g. watercourse restoration, stream restoration, improvement of trout living conditions); iii) eel-related operations (e.g. sustainable eel management; recovering and restoration of eel stock); and iv) operations related to spawning (e.g. laying of spawning gravel; improving fish spawning conditions; establishing a new spawning ground).

opportunities for the significant partnership work to be undertaken for large-scale habitat restoration, including for advice and expertise sharing between the organisations involved.

This two-year project ran from early 2019 to end of 2020 and was funded by the EMFF and the Scottish Government.

More information on the project: https://www.gallowayfisheriestrust.org/prioritised-salmon-habitat-restoration.php

4.4. Financial institutions instruments and technical support

Other means to support projects include financial products such as loans, guarantees, equity and other risk-bearing mechanisms, and technical support instruments that offer assistance in developing bankable projects.

4.4.1. Invest EU

About: Invest EU is a new (2021-2027) programme which provides bank guarantees. It is a single fund bringing together the 14 different EU-level financial instruments contributing to supporting investment in the EU in 2014-2020, including the European Fund for Strategic Investments (EFSI) and Natural Capital Financing Facility (NCFF).

It aims to support projects that are technically and economically viable by providing a framework for the use of debt, risk sharing, equity and quasi-equity instruments backed up by a guarantee from the EU budget and by financial contributions from implementing partners.

Areas of projects are divided into four windows, of which 'Sustainable Infrastructure' has the largest budget. Within this window, 60% of the operations must contribute to climate and environment objectives, while overall a 30% climate target is set for the whole programme.

The *Do no significant harm principle* - pursuant to the Taxonomy Regulation and referred to in recitals and article 7(4) of the InvestEU Regulation - applies to the whole programme, as does the sustainability proofing, to assess whether projects above a certain size have any significant environmental, climate or social impact.

The programme, which is expected to mobilise around EUR 372 billion in leveraged investments, is complementary to grant financing and other projects under the policy areas it supports, such as LIFE, Horizon Europe, the Connecting Europe Facility and the European Structural and Investment Funds.

Blending with grant financing is encouraged and will ensure complementarity with other spending programmes. For the 'Sustainable Infrastructure' window, particular attention will be focused on action to help comply with the Water Framework Directive and the Floods Directive, on investment in improving and restoring ecosystems and their services and promoting nature based solutions - for example for flood risk prevention and climate change adaptation - as well as, more generally, to natural capital.

InvestEU Advisory Hub

The InvestEU Advisory Hub provides advisory support for identifying, preparing, developing and implementing investment projects, and for improving the capacity of public and private project promoters and financial intermediaries to implement financing and investment operations.

Such support may cover any stage of a project's life-cycle or of financing for an organisation. The Hub is designed to act as a single access point to different advisory and technical assistance services. It works on the basis of five advisory products, including a specific one on InvestEU's Sustainable Infrastructure window. A portion of the LIFE budget (in total EUR 50 million from the 2021-2027 programming period) is allocated to Advisory Support Initiatives. This total budget comprises two parts:

- one part complements the Sustainable Infrastructure Advisory (SIA) under the Sustainable Infrastructure window, with the aim of helping set up projects in the environmental sector (such as water, wastewater, circular economy, biodiversity and connectivity, air pollution, etc.), and the substantial greening of other infrastructure investments (transport, energy, telecom, etc.);
- the other part supports the development and operation of a multi-disciplinary roster of experts and related services (e.g. capacity building) that can support structured green finance services on a cross-sectoral basis, including for all the four InvestEU windows.

The roster of experts will be established and operated by the European Climate, Infrastructure and Environment Executive Agency (CINEA) for the purpose of strengthening project promoters' investment teams, both helping to green traditional investment and developing 'deep green' investment, including investment in nature and nature-based solutions.

The objective of this green advisory tool is then to help public and private investment promoters and related bodies identify and develop investments that promote natural capital, the circular economy, climate change adaptation and mitigation, sustainable urban development, ecosystem-based agriculture, forestry or fisheries and, more in general, environmental-related investments.

<u>Budget 2021-2027:</u> Overall EUR 26.2 billion in budgetary guarantees, of which EUR 9.9 billion for the "Sustainable Infrastructure" window

<u>How to access funding:</u> The guarantee available under the InvestEU Fund is implemented via selected financial partners, or 'implementing partners'. The main partner is the EIB Group, which has implemented and managed EFSI since its launch in 2015, and is responsible for implementing 75% of the EU Guarantee. Additional implementing partners will be selected.

The eligible final recipients can be individuals or organisations established in an EU country or in an eligible non-EU country, including: private bodies; public sector bodies and public-sector type bodies; mixed bodies, such as public–private partnership (PPPs) and private companies with a public purpose; and not-for-profit organisations.

Project promoters should apply directly to implementing partners, who will offer tailor-made financing solutions based on the financial products supported by the EU guarantee.

The InvestEU Portal brings together investors and project promoters on a single EU-wide platform, providing a database of investment opportunities available within the EU.

<u>Example:</u> **Alzette River Renaturalisation, Luxembourg** (based on funding through a predecessor to InvestEU, the Natural Capital Financing Facility)

The restoration of the Alzette River, led by Luxembourg's Ministry of the Environment, Climate and Sustainable Development (formerly the Ministry of Sustainable Development and Infrastructure of Luxemburg), aims to re-instate some of the watercourse's natural dynamics in support of biodiversity, recreation, flood management and landscape development.

By re-establishing natural conditions, river restoration can improve the resilience of river systems and enables the sustainable multifunctional use of estuaries, rivers and streams.

The more natural flow of the river will contribute to the Habitats and the Birds Directives, as well as to Targets 2 and 3 of the 2020 Biodiversity Strategy because some stretches of the river are located in the Natura 2000 area 'Vallée de la Mamer et de l'Eisch' (LU0001018).

The project will also apply a nature-based solution to reduce the extent and frequency of flooding events which affect some downstream locations. Consequently, this project is expected to contribute to the objectives of Art 11 and Art 15 of the LIFE Regulation.

Total budget / Proposed EIB finance: EUR 12 million / EUR 9 million

More information on the project: https://www.eib.org/en/projects/pipelines/all/20170618

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