Assessment of Nature-based Solutions (NbS) for river and floodplain restoration under the EU Nature Restoration Law

Évaluation des Solutions fondées sur la Nature (SfN) pour la restauration des rivières et des plaines d'inondation dans le cadre de la Loi Européenne sur la Restauration de la Nature

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RÉSUMÉ

La mise en œuvre de la loi européenne sur la restauration de la nature (LRN) est entravée par la politique de l'UE visant à développer les énergies renouvelables, ce qui inclut également l'hydroélectricité. En outre, le rétablissement de la dynamique naturelle des cours d'eau nécessite de l'espace, de sorte que l'utilisation intensive des terres à proximité des cours d'eau doit être modifiée, ce à quoi s'opposent souvent les propriétaires fonciers et les utilisateurs des terres. Compte tenu de ces multiples conflits d'intérêts dans les corridors fluviaux, la mise en œuvre de la loi européenne sur la restauration de la nature ne semble réaliste que si l'on applique une approche intégrative prenant en compte d'autres objectifs politiques, des exigences légales, des intérêts sociétaux sectoriels et des intérêts des utilisateurs des terres. Les solutions fondées sur la nature semblent bien adaptées pour surmonter ces obstacles à la mise en œuvre de la LRN. Cependant, jusqu'à présent, les mesures courantes de restauration des cours d'eau n'ont pas fait l'objet d'une analyse systématique visant à déterminer si elles représentaient ou non des NbS. Seules quelques-unes d'entre elles ont été classées comme représentant ou non des NbS. Nous avons donc analysé 61 mesures courantes de restauration des rivières et des plaines d'inondation en fonction de leur pertinence à remplir les critères de la NbS, de leur applicabilité à plusieurs types de rivières et de leur capacité à soutenir 19 services écosystémiques.

ABSTRACT

Implementation of the EU Nature Restoration Law (NRL) is hampered by the EU policy of aiming at the expansion of renewable energies, which also includes hydropower. In addition, re-establishing natural river dynamics needs space, so that current intense land uses near river channels need to be modified, where land owners and land users are often opposing to. Given these multiple conflicts of interests in river corridors, implementation of the EU Nature Restoration Law only seems realistic if an integrative approach is applied that considers other political goals, legal requirements, sectoral societal interests, and land user interests. Nature-based Solutions (NbS) appear well suited to overcome those obstacles for the implementation of the NRL. However, so far common river restoration measures have not systematically analyzed if they represent NbS or not. Only few of them have been categorized as either representing NbS or not. Hence, we analyzed 61 common river and floodplain restoration measures for their pertinence in fulfilling NbS criteria, applicability to several river types, and suitability to support 19 ecosystem services.

KEYWORDS

ecosystem services, EU Nature Restoration Law, Nature-based Solutions, restoration measures, river types

loi européenne sur la restauration de la nature, mesures de restauration, services écosystémiques, solutions fondées sur la nature, types de rivières

1 INTRODUCTION

1.1 Background

Rivers and floodplains offer a wide variety of other provisioning, regulating, and cultural ecosystem services. Historically, humans have modified rivers and floodplains with technical measures to maximize specific natural assets, such as agriculture, navigation, or hydropower generation. However, these modifications have often led to a significant decline in the availability of other natural assets and services, including habitats for biodiversity and the self-regulating functions of river corridors. This decline has resulted in increased flooding risks, reduced self-purification capacities, and diminished drought mitigation, significantly impacting water quality and availability.

The recognition of these negative impacts has led to a shift towards multifunctional management of riverine landscapes, moving away from the historical focus on maximizing a few uses. This alternative approach aims to reactivate natural ecosystem functions to better address challenges in river management, such as flooding, drought, sediment transport, invasive species, and climate change, which often have been aggravated by the losses of system resilience due to human pollution of surface waters and hydromorphological alterations of water bodies. Novel integrative approaches in the management and restoration of river corridors are crucial in addressing the increasing challenges posed by climate change, urbanization, and ecological degradation.

This paradigm shift from conventional, engineered flood defences to more holistic, sustainable, and adaptive strategies involves integrating ecological, social, and technological dimensions. The goal is to create resilient river and floodplain systems capable of withstanding the pressures of a changing world. Nature-Based Solutions (NbS) offer integrated and multifunctional approaches to address critical societal challenges. These solutions encompass a spectrum of interventions, from minimal or no action, such as establishing conservation areas, to creating new ecosystems, including community gardens, urban parks, and mangrove restoration projects.

1.2 Nature-based solutions

Since the idea of Nature-based Solutions (NbS) was proposed, the IUCN started working on its definition for practice and, therefore, developed more concepts, clarified the terms, and put them into action through its Global Programme (IUCN, 2016). Which defines it as: "*Actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*."

The second widely accepted definition of the NbS, has been elaborated by EU projects under the European Green Deal: "*Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions*".

The Fifth Meeting of the United Nations Environment Assembly (UNEA-5) in 2022 has defined NbS as follows: "*Actions to protect, conserve, restore, sustainably use, and manage natural or modified terrestrial, freshwater, coastal, and marine ecosystems, which address social, economic, and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience, and biodiversity benefits, and recognizes that nature-based solutions … respect social and environmental safeguards* ". (UNEA, 2022).

1.3 Research question

The EU Nature Restoration Law aims to restore and protect rivers by improving their enhancing longitudinal, lateral, vertical, and temporal connectivity, especially by reconnecting at least 25,000 km of so far fragmented rivers in the EU. This necessitates restoration measures like dam and weir removal, re-establishing natural sediment load, which is based on natural river dynamics, thus also involving floodplain revitalization measures.

However, the implementation of the Nature Restoration Law is hampered by the EU policy of aiming at the expansion of renewable energies, which also includes hydropower. In addition, re-establishing natural river dynamics needs space, so that current intense land uses near river channels need to be modified, where land owners and land users are often opposing to. In some instances re-establishing natural river dynamics is also conflicting with traditional conecpts of flood protection by use of dykes and polders.

Given these multiple conflicts of interests in river corridors, implementation of the EU Nature Restoration Law

only seems realistic if an integrative approach is applied that considers other political goals, legal requirements, sectoral societal interests, and land user interests. In addition, restoration measures should be adaptable in respect to changing framework conditions due to global change.

River corridors that should serve multiple societal interests and should be resilient towards climate change must provide a wide array of ecosystem services, including providing habitats for biodiversity. A significant part of ecosystem services provided by river corridors additionally represent key prerequisites for the generation of regional socio-economic benefits, as e.g. the provision of pure drinking water or recreational opportunities. Economic benefits may in turn trigger private business to invest into nature protection programmes.

As the Nature-based Solutions (NbS) are encompassing the above mentioned goals of supporting ecosystem services, biodiversity protection, climate resilience, participatory planning and governance, NbS appear well suited to overcome obstacles for the implementation of the EU Nature Restoration Law. However, so far common river restoration measures have not systematically analyzed if they represent NbS or not. Only few of them have been categorized as either representing NbS or not. However, such rough black and white assessment ignores that restoration measures may fulfill NbS features to a gradually differing degree. Hence, we analyzed 61 common river and floodplain restoration measures for their **pertinence in fulfilling NbS criteria, applicability to several river types, and suitability to support 19 ecosystem services.**

2 METHODS

Considering the above cited definitions of NbS, especially the one by UNEA (2022), the nine NbS key criteria were extracted that are used to assess to which extent management action options are actually representing NbS. The nine criteria are grouped into three groups, as ecological criteria, socio-ecological criteria, and socio-economic criteria, plus the overarching criterion of multifunctionality concerning the nine specific NbS criteria:

Ecological criteria:

- Protection of ecosystems
- Restoration of ecosystem
- Biodiversity

Socio-ecological criteria:

- Sustainable management
- Resilience
- Ecosystem services

Socio-economic criteria:

- Climate and disaster mitigation
- Human well-being & health
- Livelihoods & economic development

Overarching criterion:

- Multifunctionality in terms of environmental, social and economic benefits

Hence, nine specific NbS criteria are used to assess if management measures are actually representing NbS by assigning NbS Pertinence Scores from 0 = no fulfilment, ’1 = low fulfilment, 2 = poor fulfilment, 3 = fair fulfilment, 4 = good fulfilment, until 5 = full fulfilment. Thereby, the assessment score for the ecosystem services criterion was taken from a detailed ecosystem services assessment matrix (see below). As NbS are expected to be multifunctional, the average of the NbS Pertinence Scores for all nine criteria is finally used to assess to which extent management actions options represent NbS. The degree to which management measures are actually fulfilling the various NbS criteria as well as requested multifunctionality is thus expressed by the resulting **NbS Pertinence Index (NbSPI)** (see ch. 3.1).

Restoring connectivity may be accomplished by different measures, depending on river type and river degradation status. Hence, the applicability and performance of management measures aiming to restore connectivity that were additionally assessed based on types of regional settings creating **river types**, as orography, flow alteration status, - morphological alterations, and - surrounding land use intensity (see ch. 3.2).

In order to provide an overview about the different degree of synergies possible with the implementation of NbS, an overview matrix was elaborated showing the degree of **support of 19 key riverine ecosystem services** (colleted by the as the German ‘River Ecosystem Service Index’ project, www.resi-project.info/en) by the 61 selected restoration measures. Assessment scores represent the extent to which the respective measure supports the respective target variable from 0 = absent, 1 = very low, 2 = low, 3 = moderate, 4 = high until 5 = very high. By calculating the average of all 19 assessments, for each measure an **Average Ecosystem Service Support Index (AESSI)** was calculated, representing the overall support effect (see ch. 3.3).

In addition, an **Index on the Number of Win-win-Successes** in terms of Ecosystem Services (**WIN_ES**X** index) when implementing a certain management measure was calculated as the number of ecosystem services supported to ‘high’ and ‘very high’ degree, in order to highlight the number of strong synergies provided by

implementing the respective measure. The WIN_ES**X index hence represents the number of actual 'winner' ecosystem services after NbS implementation.

3 RESULTS

3.1 NbS Pertinence Indexof river restoration measures

Results show that most analysed measures reach a NbS Pertinence Index (NbSPI) of 3 and 4. NbS in free-flowing sections, in floodplains and in catchments reach the highest NbSPI and are thus matching NbS criteria best. Detailed results on the NbS Pertinence Scores (NbSPI) for 61 river and floodplain restoration measures are shown in the presentation. A summary of results in the NbS Pertinence Index [NbSPI) is shown in Table 1.

Table 1: Overview on NbS Pertinence Index assessments, structured by types of management measures.

Measure type	**n**	**Minimum NbSPI**	**Maximum NbSPI**	**Average NbSPI**
Measures in the catchment	3	4	5	**4.3**
Measures in free-flowing sections	9	3	5	**4.2**
Measures in floodplains	11	4	5	**4.4**
Measures in reservoirs and impoundments	11	2	4	**3.0**
Measures at transversal barriers	27	0	5	**2.6**
All measures	**61**	**0**	**5**	**3.7**

3.2 Suitability of NbS for different river types and degrees of human modification

Table 2: Examples (3 out of 61) on the applicability of the NbS for seven river types

#	Measures in the catchment	Alpine free-flowing rivers	Mountain free-flowing rivers	Lowland free-flowing rivers rivers	Rural channelized rivers	Urban channelized rivers	Impounded rivers	Rivers with hydropower
1	Adjusting land use to reduce sediment and nutrient input		■	■	■	■	■	■
2	Reducing surface runoff through infiltration and retention		■		■	■	■	■
3	Reducing undesired (fine) sediment input		■		■	■	■	■

3.3 NbS multifunctionality regarding ecosystem services

Results on multifunctionality clearly show the win-win situations created by the synergies emerging from the implementation of multifunctional NbS measures. Thereby, multifunctionality differs significantly among the different types of measures.. A summary of results is shown in Table 3.

Table 3: Summary on the assessments of 61 NbS by the Average Ecosystem Service Support Index (AESSI), structured by types of management measures

Measure type	**n**	**Average score for provisioning ecosystem services**	**Average score for regulating ecosystem services**	**Average score for cultural ecosystem services**	**Average Ecosystem Service Support Index (AESSI)**	**WIN_ES**X**
Measures in the catchment	3	3.3	3.3	2.6	**3.0**	**6.0**
Measures in free-flowing sections	9	1.6	3.2	3.7	**2.9**	**8.1**
Measures in floodplains	11	2.1	3.7	4.0	**3.3**	**9.2**
Measures in reservoirs and impoundments	11	1.2	2.1	3.2	**2.0**	**3.0**
Measures at transversal barriers	27	1,2	1,8	3,0	**1.9**	**2.9**
All measures	**61**	1,9	2,8	3,3	**2,6**	**5,8**